DRAFT FINAL REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

Anchor QEA, LLC
614 Magnolia Avenue
Ocean Springs, Mississippi 39564

Integral Consulting Inc.
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Seattle, Washington 98104

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
95UCL	95 percent upper confidence limit
AhR	aryl hydrocarbon receptor
Anchor QEA	Anchor QEA, LLC
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
B.P.	before present
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BMP	best management practice
BSAF	biota-sediment accumulation factor
CDD	chlorinated dibenzo-p-dioxins
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cfs	cubic feet per second
CHPDD	City of Houston Planning and Development Department
COI	chemical of interest
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CT	central tendency
CTR	critical tissue residue
CU triax	consolidated-undrained triaxial
DDE	dichlorodiphenyldichloroethylene
DMP	Data Management Plan
DQO	Data Quality Objective
EMS	Environmental Management System
EPC	exposure point concentration
EqP	equilibrium partitioning

ERA	ecological risk assessment
FS	Feasibility Study
FSP	Field Sampling Plan
HASP	Health and Safety Plan
HCB	hexachlorobenzene
HQ	hazard quotient
HRGC/HRMS	high-resolution gas chromatography with high-resolution mass spectrometry
I-10	Interstate Highway 10
Integral	Integral Consulting Inc.
IPC	International Paper Company
IRIS	Integrated Risk Information System
Koc	partition coefficient of a chemical in the organic matter of soil/sediment
Kow	octanol-water partition coefficient
LOAEL	lowest observed adverse effect level
MIMC	McGinnes Industrial Maintenance Corporation
MNR	Monitored Natural Recovery
MRL	method reporting limit
MSL	mean sea level
NCP	National Contingency Plan
NPL	National Priorities List
NRHP	National Register of Historic Places
NTCRA	Non-Time Critical Removal Action
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCL	protective concentration level
PPRTV	provisional peer reviewed toxicity values
PRG	Preliminary Remediation Goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control

QC	quality control
RAO	remedial action objective
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	record of decision
SAP	Sampling and Analysis Plan
SEM	structural equation modeling
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
SOW	scope of work
SPT	standard penetration test
SSD	species sensitivity distribution
SVOC	semivolatile organic compound
TBC	to be considered
TCDD	Tetrachlorodibenzo-*p*-dioxin
TCDF	Tetrachlorodibenzofuran
TCEQ	Texas Commission on Environmental Quality
TCRA	time critical removal action
TDES	Texas Pollution Discharge Elimination System
TDSHS	Texas Department of State Health Services
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TMDL	total maximum daily load
TOC	total organic carbon
TRV	toxicity reference value
TXDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

VOC	volatile organic compound
WTP	water treatment plant

1 INTRODUCTION

This Work Plan for a Remedial Investigation/Feasibility Study (RI/FS Work Plan) was prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC) (collectively referred to as the Respondents), pursuant to the requirements of Unilateral Administrative Order (UAO), Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009, (USEPA 2009b). The 2009 UAO directs IPC and MIMC to prepare an RI/FS Work Plan for the San Jacinto River Waste Pits (SJRWP) Site in Harris County, Texas (the Site), which consists of a series of manmade impoundments used for disposal of pulp mill wastes during 1965 and 1966, and surrounding areas. The 2009 UAO also directs IPC and MIMC to submit a Screening Level Ecological Risk Assessment (SLERA), a Sampling and Analysis Plan (SAP) and a Health and Safety Plan (HASP) in conjunction with submittal of the RI/FS Work Plan. This document is the required RI/FS Work Plan, and includes the SLERA as Appendix B. The project HASP (Anchor QEA and Integral 2009) was submitted to USEPA on December 15, 2009. The draft Sediment SAP (Integral and Anchor QEA 2010) was submitted to USEPA on February 17, 2010; with revisions according to agency comments submitted on April 9, 2010; additional SAPs setting forth the quality assurance project plans (QAPPs) and field sampling plans (FSPs) will be submitted according to the RI/FS schedule provided in Section 8 of this document.

1.1 Purpose

On March 19, 2008, USEPA added the Site to the National Priorities List (NPL), and the 2009 UAO requires that an RI/FS be conducted at the Site. The RI/FS will be undertaken to address the following objectives:

- Characterize the nature and extent of Site-related contamination
- Perform a baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA)
- Evaluate the physical characteristics of the Site and physical processes governing fate and transport of Site-related contaminants
- Develop and evaluate potential remedial alternatives for the Site

The purpose of this document is to provide a comprehensive description of the work to be performed, the methods to be used, and the schedule of activities that will address these objectives. Once the RI/FS is complete, USEPA will select a Site remedy and will publish a proposed plan, which will be released for public comment. USEPA will subsequently document final selection of the remedy in a record of decision (ROD). A detailed schedule of activities leading up to submittal of the final FS Report is provided in Section 8.

1.2 RI/FS Approach and Scope

This RI/FS Work Plan was scoped following an evaluation of existing data, identification of data gaps, and a review of USEPA requirements as defined by the 2009 UAO. In addition, representatives of IPC and MIMC attended an RI/FS scoping meeting held by USEPA and attended by several other agencies on December 7, 2009; conducted a Site visit with USEPA and others on December 10, 2009; and met with USEPA and others on January 20, 2010, to discuss the approach to the RI/FS and the sediment study design that is described in the Sediment SAP (Integral and Anchor QEA 2010). USEPA and Respondents have also been actively discussing the overall Site management strategy and the project management plan. As a result of these activities, a Site management strategy, project management plan, and approach to the RI/FS have been developed, and are summarized below.

1.2.1 Site Management Strategy

The scoping process for the RI/FS has resulted in a general understanding of the types of actions that may be required to address the problems at the Site, has defined specific interim actions, and has clarified the appropriate sequence for Site actions and required investigations.

An important consideration in the development of the RI/FS Work Plan is that the original waste impoundments for the Site are considered a potential ongoing source of dioxin and furan contamination to the surrounding area in the San Jacinto River, because the original containment berms on the northwestern, northern, and eastern portions of the original impoundments are largely removed or submerged, and dioxin-bearing pulp waste is exposed to erosional forces associated with currents and tides in the river (Section 4).

According to USEPA guidance, risk management strategies for contaminated sediment sites should include early source control as part of the Site remediation (USEPA 2005a). The Respondents and USEPA are working together to implement source control actions as defined in USEPA's Time Critical Action Memorandum, dated April 2, 2010, that will be conducted concurrently with the RI/FS to minimize the continuing release of wastes from the impoundments. The Time Critical Removal Action (TCRA) would involve short-term stabilization activities on those areas of the Site that present an imminent or substantial endangerment to people or the environment. Additional actions are being taken to restrict public access. The Respondents and USEPA also plan to explore conducting a non-time critical removal action (NTCRA) to aid in the long term remedy of the Site.

The RI/FS will be used to plan the longer term stabilization, containment and removal of contaminated sediment. The overall Site management strategy is to perform immediate steps to implement source control remedies, reduce exposure and risks at the Site, to develop the information necessary to evaluate long-term remedial alternatives quickly and efficiently, and to accelerate the implementation of a final remedy for the entire area.

1.2.2 Project Management Plan

The RI/FS will be based on reliable and detailed information on the nature and extent of contamination under current (baseline) conditions, and evaluation of associated risks, processes controlling contaminant fate and transport and physical properties and conditions to allow the selection and implementation of a final remedy.

IPC and MIMC have retained Anchor QEA, LLC (Anchor QEA) and Integral Consulting Inc. (Integral) to perform the RI/FS. Figure 1-1 illustrates the organization of personnel on the project. The primary contacts for USEPA, IPC, and MIMC are provided in the next table. A description of the project organization and contacts pertaining to the RI/FS are provided after the table.

USEPA and Respondent Project Managers

Title	Name	Contact Information
USEPA Remedial Project Manager	Stephen Tzhone	U.S. Environmental Protection Agency, Region 6 1445 Ross Avenue Dallas, TX 75202-2773 (214) 665-8409 tzhone.stephen@epa.gov
International Paper Company Project Manager	Philip Slowiak	6400 Poplar Avenue Memphis, TN 38197-0001 (901) 419-3845 philip.slowiak@ipaper.com
McGinnes Industrial Maintenance Corporation Project Manager	Andrew Shafer	9590 Clay Road Houston, TX 77080 (713) 772-9100 Ext. 109 dshafer@wm.com

The following table shows the names, quality assurance (QA) responsibilities, and contact information of key project personnel for Anchor QEA and Integral in performance of the RI/FS. Additional roles and related personnel required for execution of specific investigation are specified in SAPs.

Project Personnel Quality Assurance Responsibilities

Title	Responsibility	Name	Contact Information
Project Coordinator	Coordination of project information and related communications on behalf of IPC and MIMC with USEPA; liaison between USEPA project managers and respondent project managers.	David Keith	Anchor QEA, LLC 614 Magnolia Avenue Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com
Anchor QEA Project Manager	Project planning and implementation; liaison between respective internal and external team members.	David Keith	Anchor QEA, LLC 614 Magnolia Avenue Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com

Title	Responsibility	Name	Contact Information
Integral Project Manager	Project planning and implementation; liaison between respective internal and external team members.	Jennifer Sampson	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0351 jsampson@integral-corp.com
Anchor QEA and Integral Corporate Health and Safety Managers	Oversight of health and safety program for field tasks associated with RI/FS.	David Templeton	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 dtempleton@anchorqea.com
		Eron Dodak	Integral Consulting Inc. 319 SW Washington Street Suite 1150 Portland, OR 97204 (503) 284-5545 edodak@integral-corp.com
Project Database Administrator Integral	Database development and data management.	Dreas Nielsen	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0311 dnielsen@integral-corp.com
Laboratory QA Coordinator for Study Elements 1 and 2 Integral	Completeness of QA documentation and procedures; liaison between project personnel, laboratories, and data validators and for related QA communications with USEPA.	Craig Hutchings	Integral Consulting Inc. 1205 West Bay Dr. NW Olympia, WA 98502 (360) 705-3534 chutchings@integral-corp.com
Laboratory QA Coordinator for Study Elements 3 and 4 Anchor QEA		John Laplante	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 jlaplante@anchorqea.com

Anchor QEA and Integral plan to undertake an adaptive and iterative management approach to the RI/FS process. In this approach high-value work is identified in conjunction with USEPA, IPC, and MIMC and prioritized to be completed early in the RI/FS process. As each work element is completed, the results are evaluated; the understanding of the Site updated, and plans for future work are revised as appropriate. The order of future work will be prioritized based on the Site's needs. Existing and new data will be used for building a better conceptual understanding of the Site and a remedial solution for the Site.

The RI/FS team will evaluate existing and newly collected data at each step in the RI/FS process to determine if there are opportunities for early removal actions and/or controls that would significantly reduce risk posed by the Site.

This document and the sediment SAP (Integral and Anchor QEA 2010), Data Management Plan (DMP) (Appendix A), and HASP (Anchor QEA and Integral 2009) provide administrative and programmatic direction for the project and are the foundation of subsequent work packages (either Work Plans or SAPs) for the RI/FS. If needed, addenda to the HASP and other global plans will be prepared for each SAP to cover activities outside of the scope of the global documents.

Work packages, consisting of SAPs and/or technical memoranda, will be prepared detailing each specific investigation or other work that will occur according to the schedule provided in Section 8. This process will continue until the RI is completed. Based on a review of the considerable amount of historical data that is available for the Site, and other information, the major elements anticipated for the San Jacinto RI/FS include the following:

- Nature and Extent Data Collection and Analysis
- Ecological and Human Health Risk Assessment Data Collection and Evaluation, including bioaccumulation data collection and modeling
- Chemical Fate and Transport Data Collection and Evaluations, including hydrodynamic and sediment stability data collection and modeling and surface water modeling
- Feasibility Study Engineering Data Collection and Evaluations

The focus of each of these work elements is discussed in more detail in this RI/FS Work Plan. During preparation of each work package, and after the evaluations of data associated with each work package are completed, the Respondents' technical team will provide interim reports (according to the 2009 UAO) to the respondents and agencies to keep team members apprised of the progress of the project. Work package deliverables subsequent to this Work

Plan that will describe the specific methods and approaches for addressing data gaps include the following:

- Technical Memorandum on Fate and Transport Modeling, and Addendum to the Sediment SAP
- Technical Memorandum on Bioaccumulation, and Tissue SAP
- Soil SAP
- Groundwater SAP
- Exposure Assessment Memorandum
- Toxicological and Epidemiological Studies Memorandum

The first two technical memoranda will provide the information required in the "Technical Memorandum on Modeling of Site Characteristics" identified by the 2009 UAO. These memoranda will evaluate relevant information and identify data necessary for modeling (i.e., the data gaps), and the SAPs that accompany these memoranda will address those data gaps. The Soil SAP will address data gaps for soil identified later in this document. The last two memoranda are stipulated by the 2009 UAO, and address methodological issues related to the human health risk assessment. A work plan for performance of the BERA is not planned for this project, but Section 6.4 of this document provides the approach to the BERA, and details presented in the DQOs of each SAP articulate the anticipated role of each new data set in the BERA. The schedule for these, and for the other deliverables required by the 2009 UAO, is provided in Section 8. It is likely that the COPC selection criteria outlined in this document will fulfill the requirements of the preliminary contaminant of concern (PCOC) memorandum required in the UAO. Any need for additional analyses, memoranda, and SAPs will be determined in consultation with USEPA.

1.3 Work Plan Organization

The following sections of this Work Plan provide a history of the Site and describe the physical and chemical setting (Section 2), an assessment of data quality and usability (Section 3), a description of the current Conceptual Site Model (CSM) (Section 4), a review of study elements and data needs (Section 5), a description of the RI and FS approaches (Sections 6 and 7, respectively), and the proposed RI/FS schedule (Section 8). Supporting information is provided in the following Appendices:

Appendix A – Data Management Plan

Appendix B – Screening Level Ecological Risk Assessment

Attachment B1 – Ecological Receptors Potentially Present at the Site

Attachment B2 – Overview of Toxicity of Dioxins and Furans to Ecological Receptors

Appendix C – Chemicals of Interest and Selection of Chemicals of Potential Concern

Appendix D – Data Quality and Usability Assessment Checklists

Appendix E – Geochemical Characteristics of Primary COPCs

Appendix F – Select Boring Logs From Within the Preliminary Site Perimeter

Appendix G – Response to Agency Comments on the Draft RI/FS Work Plan

2 PROBLEM DEFINITION

2.1 Site History

The Site consists of a set of impoundments approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The set of impoundments is located on a partially submerged 20-acre parcel of real estate on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2-1).

USEPA has information that indicates an additional impoundment is located south of I-10. This information indicates the additional impoundment contains material similar to that disposed of in the two impoundments described above. USEPA has not identified any evidence of releases or threatened releases from the additional impoundment. Six sediment samples were taken in the Old River area south of I-10, adjacent to the potential impoundment. The six sediment samples were collected as part of the April 2010 approved "Sampling and Analysis Plan: Sediment Study San Jacinto River Waste Pits Superfund Site," and results from the sampling will be reported as part of the RI/FS process.

In 1965, the impoundments north of I-10 were constructed by forming berms within the estuarine marsh, to the west of the main river channel. These impoundments at the Site were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm, into the impoundment located to the east of the central berm (Figure 2-1). The excess water collected in the impoundment located to the east of the central berm was pumped back into barges and taken off-Site. In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were reportedly transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas and unloaded at the Site into the impoundments north of I-10 where the waste was stabilized and disposed. The excess water from these impoundments was pumped back into barges and taken off-Site. The Champion Paper mill used chlorine as a bleaching agent, and the wastes that were deposited in the impoundments have recently been found to be contaminated with polychlorinated dibenzo-p-dioxins, polychlorinated furans (dioxins and furans), and some metals (TCEQ and USEPA 2006); additional discussion of the chemical constituents typical of materials like those deposited in the impoundments is provided in Section 1.5 of the Sediment SAP (Integral and Anchor QEA 2010). The impoundments north of I-10 were used for waste disposal from September 1965 through late 1966, until both impoundments were filled to capacity. Since the eastern impoundment was used to dewater the western impoundment (as noted above), the capacity of the eastern impoundment for waste disposal is thought to have been less than that of the western impoundment.

Physical changes at the Site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. Based upon review of U.S. Army Corps of Engineers (USACE)-approved dredging permits, dredging by third parties has occurred in the vicinity of the perimeter berm at the northwest corner of these impoundments. Recent samples of sediment in nearby waters north and west of these impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than levels in background areas nationally (USEPA 2000).

Freshwater, estuarine, and marine habitats in the vicinity of the Site are shown in Figure 3. Residential, commercial, industrial, and other land use activities occur within the preliminary Site perimeter and in the surrounding area. Residential development on the eastern bank of the river is present within 0.5 mile of the Site. The impoundments north of I-10 are currently occupied by estuarine riparian vegetation to the west of the central berm, and are consistently submerged even at low tide to the east of the central berm. Estuarine riparian vegetation lines the upland area that runs parallel to I-10 and the uplands west of the impoundments. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2-1).

2.2 Physical Setting

The physical setting of the Site is described in this section. Consistent with USEPA guidance (USEPA 1988a), this discussion emphasizes factors that are important in developing the CSM for the Site.

2.2.1 Overview

The Site is within the estuarine portion of the lower San Jacinto River. Movement of contaminants into and out of the Site is expected to occur primarily through the movement of sediments, but other modes of transport are also possible. Upstream conditions may have influenced sediment conditions on the Site, and will continue to do so in the future.

2.2.2 Watershed Characteristics and Galveston Bay Ecosystem

The San Jacinto River drains an area of 3,900 square miles and supplies approximately 28 percent of the fresh water entering Galveston Bay (Gardiner et al. 2008). The mainstem of the San Jacinto River, downstream from the Lake Houston dam in northeastern Harris County, flows southeast for 28 miles to its mouth on Galveston Bay east of Houston. The 9-mile-long Lake Houston and the river below it are formed by the confluence of the 69-mile-long East Fork and the 90-mile-long West Fork of the San Jacinto rivers. The dam that forms Lake Houston is an earthfill dam that is 62 feet high with a concrete spillway. The reservoir that is created by the dam is used for recreation, as well as an industrial, municipal, and agricultural water supply.

The Houston Ship Channel which was created in 1914, was dredged and widened the lower San Jacinto River (dredging did not extend as far upstream as the Site) to link the Port of Houston with Galveston Bay and the Gulf of Mexico. It is likely that construction of the Houston Ship Channel directly altered surface water circulation by providing a larger cross-section for north to south water movement on the main axis of the bay and by breaching Redfish Bar, which had previously limited water exchange between the upper and lower bay (Lester and Gonzalez 2005).

The Site is located in a hydrologically dynamic tidal section of the San Jacinto River. Wildlife habitats on the northern portion of the Site include shallow and deep estuarine waters and shoreline areas occupied by estuarine riparian vegetation. Minimal habitat is present in the upland terrestrial area west of the impoundments, as sand sorting activities created a denuded upland area with a covering of crushed cement and sand. The sandy shoreline of this area is littered with riprap, other metal debris, and piles of cement fragments. Estuarine riparian vegetation lines the upland area that runs parallel to I-10. To the west of the central berm within the impounded area, the area is currently occupied by late successional stage vegetation, and to the east the historically impounded area is consistently submerged even at low tide.

2.2.3 Land Use

The San Jacinto River watershed is one of several larger watersheds in the greater Houston area and encompasses nearly 4,000 square miles (Figure 2-3). Within this large area, which extends more than 80 miles north of the Site the land type varies from farmland, parks, and undeveloped lands to urban and industrial areas. The land type typical of the area surrounding the Site is shown in Figure 2-2 and is better described within the appropriate sub-basin that is mapped within the San Jacinto watershed. There are three sub-basins within the larger San Jacinto watershed that are in the vicinity of the Site. These include The San Jacinto River Tidal, Houston Ship Channel, Houston Ship Channel/San Jacinto River, which are highlighted in Figure 2-4. Within these areas, the land parcels closest to the Site are predominantly commercial/industrial, followed by residential areas. As you move further from the Site, the amount of residential land use increases, along with other land use categories not found in the immediate vicinity of the Site, such as undeveloped land, farms, parks, and lands listed as other (e.g., schools and hospitals). Generally development is more intense near the San Jacinto River and Houston Ship Channel to the south.

Land uses upstream include industrial and municipal activities that may result in releases of dioxins and furans or other COPCs in to the San Jacinto River upstream of the Site. Several facilities with discharge permits are located on lands upstream and downstream of the Site. All of the permitted facilities discharging to water quality segment 1001 shown in Figure 2-4 and listed in Table 2-1 (discussed further below) are part of the National Pollution Discharge Elimination System (NPDES) which assigns effluent limitations for a variety of chemical constituents but does not address dioxins and furans. The TCEQ's Houston Ship Channel

TMDL project for dioxin, which began in May of 2000, was implemented as a result of the Texas Department of Health seafood consumption advisory for catfish and blue crab issued in 1990. The goal of the TMDL project is "to determine the measures necessary to restore water quality to water bodies affected by the consumption advisory" (TCEQ 2010). The TMDL project included an effort to sample sludges and effluents at facilities throughout the HSC area, including areas upstream of the Site. Facilities volunteered to have effluents or sludges sampled; the absence of a sample is not an indication that the facility is not a potential contributor of dioxins and furans to the San Jacinto River. Both the discharge permits and the TMDL sludge and effluent information are relevant to planning the RI/FS investigation because the upstream condition affects risk management decisions for the Site (USEPA 2002d), and potential upstream sources should therefore be considered. This section lists those facilities permitted to discharge to water quality segment 1001 (which extends upstream from the Site to a point just south of Lake Houston). Whether sludge or effluent sampling was performed by the TMDL project at the facility, confirming the presence of dioxins and furans in sludges or effluents is noted in Table 2-1. Figure 2-4 shows the locations of facilities with discharge permits and the of sludge or effluent samples that are listed in Table 2-1.

There are six registered discharge permits upstream of the Site on the San Jacinto River (Figure 2-3: Table 2-1). The facilities listed in Table 2-1 range from one to eight miles upstream of the Site. The City of Baytown – West District Water Treatment Plant (WTP) (NPDES ID TX0072834) is the closest facility, located just over 1 mile to the east of the impoundments. Further upstream are two chemical manufacturing facilities, an industrial facility, and two more WTPs. According to permit records, all of these facilities discharge to river segment 1001 of the San Jacinto River. The Texas Pollution Discharge Elimination System (TPDES) permits for the WTP facilities list carbonaceous biochemical oxygen demand, total suspended solids, ammonia nitrogen, and total Kjeldahl nitrogen as the regulated effluent characteristics for operating the facilities. The TPDES permits for the Donohue Industrial Facility upstream of the Site lists biological oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids as the regulated effluent characteristics for this facility. The two chemical manufacturing facilities Lyondell Chemical and Channelview Complex (Equistar), also both upstream of the Site, have the largest lists of regulated effluent characteristics, both of which include extensive lists of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs).

Table 2-1
NPDES-Permitted Facilities Upstream of The Site

	Facility Name	NPDES Permit ID	Notes	A Sludge or Effluent Sample was Collected and Dioxins and Furans Were Found
1	NEWPORT MUD WWTP	TX0023230	Permitted Discharger	X
2	DONOHUE INDUSTRIES INCORPORATED	TX0053023	Permitted Discharger	
3	EQUISTAR CHANNELVIEW COMPLEX	TX0003531	Permitted Discharger	X
4	LYONDELL CHEMICAL CHANNELVIEW	TX0069493	Permitted Discharger	X
5	HARRIS COUNTY WCID NO. 1 WWTP	TX0023311	Permitted Discharger	X
6	BAYTOWN WEST 1	TX0072834	Permitted Discharger	X

2.2.4 Climate

The climate along the Gulf Coast of Texas and the area surrounding Houston is humid subtropical. The average annual precipitation is 54 inches, the warmest month is July, with an average temperature of 85°F, and the coldest month is January, with an average temperature of 54°F. Prevailing wind directions for the region are primarily from the south or southeast. During the spring season large thunderstorms are common and are capable of producing tornados. This transition to the summer months with mild temperatures noted above, but relative humidity that can reach upwards of 90 percent and results in a heat index much higher.

Monthly rainfall data over a 10 year period was tabulated and the average monthly precipitation is shown in Figure 2-5. The monthly average precipitation varies from approximately 2.5 inches in February to over 7 inches in June. The figure shows that from a high in June, average monthly rainfall drops until October, where there is another abrupt increase followed by another decline. This decline leads into the winter months before reversing in late winter into early spring, where monthly average values once again increase, until reaching their peak in June.

It is not uncommon to have precipitation events that exceed 2 inches per day, and on a 10-year basis, events that exceed 10 inches per day should be expected. These types of precipitation events produce wide variations in the volume of discharge into and out of the San Jacinto River and have significant implications concerning variations in flow velocities, sediment stability, and suspended sediment loads.

Tropical weather systems can have tremendous impacts on regional precipitation and hydrology along the Gulf Coast. Hurricane season runs from June 1 to November 30. Between 1851 and 2004, 25 hurricanes have made landfall along the north Texas Gulf Coast, seven of which were major (Category 3 to 5) storms (NOAA 2005). Tropical Storm Allison, which hit the Texas Gulf Coast on June 5 through 9, 2001, resulted in 5-day and 24-hour rainfall totals of 20 and 13 inches, respectively, in the Houston area, resulting in significant flooding. More recently, Hurricane Rita made landfall on September 23, 2005, between Sabine Pass, Texas, and Johnsons Bayou, Louisiana, as a Category 3 on the Saffir-Simpson Hurricane Scale, with winds at 115 mph and it continued on through parts of southeast Texas. The storm surge caused extensive damage along the Louisiana and extreme southeastern Texas coasts. On September 13, 2008, the eye of Hurricane Ike made landfall at the east end of Galveston Island and travelled north up Galveston Bay, along the east side of Houston. Ike made its landfall as a strong Category 2 hurricane, with Category 5 equivalent storm surge, and hurricane-force winds that extended 120 miles from the storm's center.

2.2.5 Regional Geology

Sediments of the Texas Gulf Coast are generally Cenozoic fluvial-deltaic to shallow-marine deposits of a coastal plain environment (USGS 2002). Sea-level transgression-regression cycles and natural basin subsidence have produced beds of clay, silt, sand and gravel that gently dip southeast towards the Gulf of Mexico. This complex depositional process created both a continental assemblage of sediments that now makes up the aquifers within the area and a marine sequence of sediments that contain clay layers and confining units. This process resulted in a regional aquifer system with a high degree of heterogeneity in both lateral and vertical extent (USGS 2002) commonly referred to as the Gulf Coast Aquifer System (GCAS; TNRCC 1999). The unconsolidated deposits mapped within the area of the Site are shown in Figure 2-6.

2.2.6 Local Geology

In the Site area, the surface and underlying local soils include Holocene alluvial deposits and the Beaumont formation, which is the youngest and uppermost of the series of coast-parallel Pleistocene deposits that make up the GCAS. The soils of the Beaumont formation are dominated by clays and silts that thicken seaward that were deposited in a fluvial-deltaic environment (Van Siclen 1991). The Beaumont formation and overlying recent alluvial soils make up the uppermost units of the Chicot Aquifer (USGS 2002) which is discussed along with the Evangeline Aquifer in section 2.2.7 below.

Figure 2-7 shows a fence diagram of former containment berm soils and river sediments in the Site vicinity, based on recent geotechnical borings completed at the Site[1] and four borings completed by the Texas Department of Transportation (TXDOT). The locations of the recent geotechnical and TXDOT borings shown in the fence diagram, along with the boring logs are included in Appendix F as Figures F-1 through F-10. The map location of the diagram on Figure 2-7 is shown on Figure F-10. Grain size data from the TXDOT borings have been incorporated into the analysis of soil and sediment stratigraphy shown on Figure 2-7. The soil borings confirm the presence of berms soils and recent alluvial sediments (interbedded clays, silts and sands), underlain by approximately 10 to 20 feet of the Beaumont formation. The boring logs included in Appendix F show histograms of the grain size distribution where data was collected and analyzed. The boring logs and grain size information presented in Appendix F clearly show the presence of the Beaumont Formation underlying the alluvium at the Site. The thickness and extent of the Beaumont Formation are shown on Figure 2-7. Additional discussion of the regional and local hydrogeology follows.

[1] The recent geotechnical borings noted here were collected as part of the sediment sampling for the RI/FS required by the 2009 UAO. Methods for their collection are as described in the Sediment SAP (Integral and Anchor QEA, 2010).

2.2.7 Regional Hydrogeology

The GCAS is located along the coast of the Gulf of Mexico and has been divided into four units; the Chicot and Evangeline Aquifers, Burkeville confining unit, and Jasper Aquifer. Each of these hydrogeologic units has particular hydrogeologic properties. The Site, located in Harris County, is above the Evangeline and Chicot Aquifers as shown in Figure 2-8. The Evangeline Aquifer is the deeper aquifer and it consists of the Goliad Sand Formation, which overlies the Burkeville confining unit of the Fleming formation (not shown). The Burkeville unit is considered the basal unit within the Houston area and is a "no-flow" unit that separates the two above-mentioned aquifers from the more dense saline waters below. The base of the Evangeline Aquifer ranges from 5,000 feet below mean sea level (MSL) south of the coastline to slightly more than 200 feet above MSL at its northern, up-dip extent. The aquifer extends as far north as Washington County, Walker County, and surrounding counties and is thinnest in the up-dip direction. The Evangeline Aquifer has shallow water table conditions in these locations and becomes confined when moving southward through the Houston area toward the coast (USGS 2002).

The local stratigraphy at the Site, as described above, makes up the uppermost units of the Chicot Aquifer. In stratigraphic order from youngest to oldest, the Chicot Aquifer consists of the Holocene surficial river alluvium underlain by and the Beaumont, Montgomery and Bentley Formations, and Willis Sand Formations [USGS 2002]). The formations within in Chicot Aquifer are shown on the inset table on Figure 2-6. Similar to the Evangeline Aquifer, the Chicot Aquifer extends from the coastline to the north of Houston into Austin, Waller, Polk, and surrounding counties, but not as far north as the Evangeline aquifer (Figure 2-8). The base of the Chicot Aquifer is located more than 1,500 feet below MSL near the coast, to more than 100 feet above MSL near the upland limit of the aquifer. Like the Evangeline, the Chicot Aquifer has shallow water table conditions in upland locations and becomes confined by the Beaumont Formation clays and silts moving south through the Houston area toward the coast.

Groundwater elevation maps for the Evangeline and Chicot Aquifers show that regional groundwater flow is directed down dip (i.e., approximately southeast) towards the Gulf of Mexico (USGS 2002). On a net flow basis, shallow groundwater discharges to the river and provides some of the river baseflow. Under high tide and river flow conditions, it is expected that a temporary gradient reversal will exist which causes rivers water to temporarily recharge the shallow alluvium adjacent to the river. Recharge to the Chicot Aquifer primarily occurs in the northern up-dip outcrop areas shown in Figure 2.9 where the Beaumont Formation is thinner or nonexistent. This area of recharge for the Chicot Aquifer is well up-gradient from the Site. As described later in this report, the fine-gradient Beaumont Formation separates the shallow alluvium from the underlying formations of the Chicot Aquifer and greatly restricts any recharge that might occur from alluvium to the Chicot formations underlying the Beaumont (USGS 1997).

The Chicot Aquifer is used as a drinking water source within the greater Houston area, but water used for this source is pumped from wells screened much lower in the aquifer (i.e., below the Beaumont formation). Although there are some upper Chicot Aquifer wells, privately owned, near the Site (see below), infiltrating surface waters or shallow groundwater would likely be prevented by the thick sequence of the clay and silt deposits of the Beaumont formation, effectively isolating confining the lower portion of the Chicot Aquifer from shallower groundwater and surface water in the Site vicinity (USGS 2002).

2.2.8 Local Hydrogeology

The local water table (i.e., shallow groundwater) is found near land surface in the shallow alluvium sediments, generally at the approximate elevation of the San Jacinto River water surface. Groundwater movement in the shallow alluvium in the Site area is dominated by surface water/groundwater interactions with the river, which surrounds the former impoundments. In regions such as the Site area (i.e., shallow water table, relatively flat topography), groundwater discharges to surface water bodies (Fetter 1994; Freeze and Cherry 1979). This reach of the San Jacinto River watershed is characterized by extremely flat groundwater gradients indicating that the area surrounding the Site is an area of minimal recharge to the aquifers (see Figure 2-9). The Beaumont Formation under the Site is a confining unit that isolates shallow groundwater in the Holocene alluvium and in the San Jacinto River sediments from the underlying formations of the Chicot Aquifer. This presence of the Beaumont Formation underlying the alluvium is shown on the fence diagram in Figure 2-7, and in Appendix F.

There are three groundwater wells near the east bank of the San Jacinto River that are within approximately 3,000 feet of the impoundments (Figure 2-6, Table 2-2). The Harris County WCID 1 (#6516506) well penetrates the Lower Chicot Aquifer at a depth of 537 feet (elevation -497 feet MSL) and is approximately 1,000 feet due east of the former impoundments. A well owned by C. Fitzgerald (#6516812) penetrates the Upper Chicot Aquifer at a depth of 125 feet (elevation -95 MSL) and is approximately 1,900 feet southeast of the former impoundments. A well owned by Vahlco Corp (#6516811) penetrates the Lower Chicot Aquifer at a depth of 530 feet (elevation -94 MSL) and is approximately 3,500 feet south of the former impoundments.

Table 2-2
Registered TWDB Groundwater Wells Near The Site

TWDB Well Number	Owner	Top of Well Elevation (feet)	Well Depth (feet)	Aquifer
6516506	Harris County WCID 1	40	537	Lower Chicot
6516811	Vahlco Corp	32	350	Lower Chicot
6516812	C. Fitzgerald	30	125	Upper Chicot

Given that these potable water wells are screened within or below the Beaumont formation, it is expected that their water quality would be different than the relatively brackish, non-potable shallow groundwater adjacent to the river and potentially influenced by the San Jacinto River. Since the San Jacinto River is in a tidal estuary, the river water has a very high natural salt content and total dissolved solids, which should be reflected in shallow groundwater near the former impoundments. Figures 2-10 and 2-11 depict water quality data from wells 6516811 and 6516812, collected in 1972 (TWDB 2010), screened in the Lower Chicot, and water quality data from the San Jacinto River. Note, that these well completion data from 1972 are the only publicly available data for these wells. The data shown for the San Jacinto River is an average of all data collected in 2009 from station 11193 (HGAC 2010) as river data does not exist from 1972 when the wells were sampled. The data are presented on a Stiff diagram (Figure 2-10) and Piper diagram (Figure 2-11). These are commonly used graphical presentations for water quality data used to determine water source similarities and differences by comparing concentrations of common cations and anions. The signature of the San Jacinto River water is markedly different than the two monitoring wells on both the Stiff diagram and Piper diagram, indicating two distinct water sources and that the Beaumont Formation effectively isolates the Chicot Aquifer from recharge from shallow groundwater in the Site vicinity. Because the depth of the channel of the San Jacinto River is deeper than the depth of the base of the impoundments, it can be assumed that the Beaumont Formation not only acts as an aquitard that keeps saline surface water from infiltrating into potable water supplies in the Chicot, but that the Beaumont also is an effective aquitard to saline shallow groundwater surrounding the Site.

Given the above described local hydrogeology, water quality analysis and regional recharge considerations, it is unlikely that shallow groundwater in general, or any Site related contaminants of concern specifically would affect local wells. In order for shallow groundwater near the Site to affect local wells in the Chicot Aquifer, groundwater from the Site alluvial sediments would have to overcome significant surface water/groundwater interactive forces, penetrate up to approximately 20 feet of Beaumont Formation clay and silt, which has been shown to confine the Chicot aquifer in the region by the USGS (2002), and flow under the San Jacinto River to reach these wells—a very unlikely scenario. No data are available to demonstrate that either these three wells or any other public water supply wells have been impacted or are threatened by Site related contaminants. Finally, the main Site COPCs, dioxins/furans, strongly adsorb to soil particles and are believed to be virtually immobile in the subsurface (Fan et. al. 2006; USAF 2006; ATSDR 1998), further decreasing the likelihood of contaminant transport by groundwater from the Site to these distant wells. ATSDR (1998) indicates that chlorinated dibenzo-p-dioxins (CDDs) "…bind strongly to the soil, and therefore are not likely to contaminate groundwater…" and "CDDs are unlikely to leach to underlying groundwater…"

2.2.9 Surface Water Use

South of the dam at Lake Houston, the San Jacinto River, including the area surrounding the Site, is tidally influenced. The area south of the Site is dominated by the Houston Ship Channel and the industrial sites that are served by the barges and ocean going vessels that use the channel. From the preliminary Site perimeter north to Lake Houston there is much less industrialization along the river because the Houston Ship Channel turns west south of the Site. The water quality segments upstream and downstream of the Site include the following uses (listed in Table 2-3): aquatic life, general, recreation and restricted fish consumption. The river segments of interest are segments 1001 and 1005. River segment 1001, which includes the study area, begins at a point 100 meters downstream from the I-10 Bridge and continues north until reaching Lake Houston. Segment 1005 begins at the same point below the I-10 Bridge and continues downstream to the confluence with Galveston bay at Morgan's Point. Fish consumption in the San Jacinto River, both up and downstream of the Site is restricted, due to the elevated concentrations of polychlorinated biphenyls (PCBs) and dioxins and furans found in fish and crab tissue (TCEQ 2010). Detailed descriptions of all restrictions in segment 1001 of the San Jacinto River are provided in detail online (http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/305_303.html#fy2010) and are posted on signs at locations along the river. In all but one of the segments, the river is considered suitable for aquatic life and recreation. This unsuitable area is located in the Houston Ship Channel after it turns west from the San Jacinto River and is likely the result of the heavy industrialization and vessel traffic along this portion. The remaining water quality segments are deemed suitable for these activities.

Lynchburg Reservoir, located on the east bank of the San Jacinto River just south of the I-10 Bridge, uses off-channel water from the San Jacinto River in Harris County, Texas. It is owned by the City of Houston, and construction was completed in 1976. At normal levels the lake has a surface area of 200 acres. The lake dam is earthen construction, with a height of 35 feet and a length of 15,315 feet. The lake capacity is 5,188 acre feet; however, normal storage is 4,700 acre feet. The lake drains an area of 0.32 square miles. Lost Lake (located south of I-10 between the primary channel of the San Jacinto River and the Old Channel to the west) is not a surface water reservoir; rather, it is a confined disposal facility for sediments from the Houston Ship Channel maintenance dredging program. It is managed by the Port of Houston Authority and USACE, Galveston District.

Table 2-3
San Jacinto River/Houston Ship Channel Water Quality Segments

Stream Segment	Segment Name	Location	Aquatic Life	Recreation	Fish Consumption	General
1001	San Jacinto River Tidal	Upstream	A	A	R	A
1005	Houston Ship Channel/San Jacinto River Tidal	Downstream	A	A	R	R

A = Approved R = Restricted

2.2.10 Hydrography

Flow rates in the San Jacinto River in the vicinity of the Site are partially controlled by the Lake Houston dam, which is located about 28 miles upstream of the waste impoundments. The average flow in the river is 2,200 cubic feet per second (cfs). Floods in the river primarily occur during tropical storms (e.g., hurricanes) or intense thunderstorms. Extreme flood events have flow rates of 200,000 cfs or greater. The October 1994 flood had a peak discharge of 360,000 cfs, which has a return period of greater than 100 years. River stage height during the October 1994 had a maximum value of 27 feet above MSL.

The river in the vicinity of the waste impoundments is affected by diurnal tides, with a typical tidal range of 1 to 2 feet. Tidal range varies over a 14-day cycle, with neap and spring tide conditions corresponding to minimum and maximum tidal ranges, respectively. Tropical storms and wind storms from the north can have significant effects on water levels at the Site. Tropical storms can cause storm surges with water levels that are significantly higher than typical tidal elevations. Storms with strong winds from the north can cause water to be transported out of the Galveston Bay system which can result in water levels that are much lower than low tide elevations.

Salinity in the vicinity of the waste impoundments generally ranges between 10 and 20 parts per thousand during low to moderate flow conditions in the river. During floods, salinity values will approach freshwater conditions.

2.2.11 Sediment Physical Characteristics

Four distinct types of sediment particles are found in the sediment bed: 1) clay (particle diameter less than 2 microns); 2) silt (particle diameter 2 to 62 microns); 3) sand (particle diameter 62 to 2,000 microns); and 4) gravel (particle diameter greater than 2,000 microns). The sediment bed is composed of varying amounts of clay, silt, sand, and gravel. Within the unconsolidated sediments in the Site area (Section 2.2.5), the sediment bed may be separated into two distinct categories (or bed types): 1) non-cohesive; and 2) cohesive. A non-cohesive bed is primarily composed of sand and gravel, with relatively small amounts of clay and silt. Non-cohesive (sandy) bed areas are usually found in locations with relatively high hydrodynamic energy, such as the main channel of the river. A cohesive bed is primarily composed of clay, silt, and fine sand (62 to 250 microns), with relatively small amounts of coarse sand and gravel. Cohesive (muddy) bed areas generally occur in locations with relatively low hydrodynamic energy, such as shallower areas that are adjacent to the main channel.

2.2.12 Sediment Transport

Sediment is transported in the San Jacinto River, and within the vicinity of the waste impoundments, by two modes: 1) bed load; and 2) suspended load. Typically, bed load transport is relatively small when compared to suspended load transport. In addition, bed load transport will generally be limited to non-cohesive bed areas within the main channel.

A portion of the sediment transported down the San Jacinto River will be deposited within the area of the Site, due to a widening of the channel and dispersal of sediment into the shallower areas adjacent to the channel. Due to relatively high flow rates in the river during floods, a large majority of the annual sediment load is transported during a small number of floods each year. This process will result in episodic deposition during floods (i.e., a layer of sandy or muddy sediment being deposited) at various locations within the area of the Site. Due to increased current velocities during floods, bed scour may also occur at some locations in the Site area during these events.

2.3 Chemical Setting

There are currently several data sets available to describe chemical contamination in the environment at the Site and in the nearby area; the available data that will be used to define the baseline condition are summarized in Table 2-4. Determination of whether any of these data sets can be used to describe the baseline condition at the Site will be made using results of sediment sampling, as described in the Sediment Sap. This section describes the existing chemical conditions in the vicinity of the Site using the available data for the following media:

- Surface water
- Sediment
- Biological tissue

In addition, several studies have been conducted in the local area, which provide important context and insights on contaminants in the environment in the vicinity of the Site:

- Louchouarn and Brinkmeyer (2009)
- Houston Ship Channel toxicity study (ENSR and EHA 1995)
- Frank et al. (2001)
- Texas Department of State Health Services (TDSHS) fish consumption advisories

Data for these studies were either not available for the RI/FS scoping process, or were collected prior to 2000. The sections below summarize the available information, including some data analyses.

2.3.1 Soil

There are currently no chemistry data for soils collected from the Site.

2.3.2 Sediment

The preliminary Site perimeter identified in the 2009 UAO is within the estuarine portion of the lower San Jacinto River, in an area from which sediments have previously been sampled for several studies (Table 2-4 and Figure 2-12). The studies or programs providing sediment chemistry data that addresses the objectives of one or more study elements for the RI/FS include the following:

- The Screening Site Inspection Report (TCEQ and USEPA 2006)
- Sampling for the I-10 dolphin project (Weston 2006)
- The Houston Ship Channel dioxin Total Maximum Daily Load (TMDL) study (University of Houston and Parsons 2006)
- Samples collected for Texas Commission on Environmental Quality (TCEQ) in August 2009 (URS 2010)
- Data generated by the November 1, 2009, Permit Evaluation Process initiated by USEPA, USACE, and TCEQ, and managed by TCEQ (USEPA et al. 2009); this currently includes a data set for one permit application (Orion 2009)
- The Houston Ship Channel Toxicity Study (ENSR and EHA 1995)
- The Houston Ship Channel PCBs TMDL study (University of Houston and Parsons 2009; Koenig 2010, pers. comm.)

Within the preliminary Site perimeter, surface sediment samples have been collected from 50 locations, and sediment cores have been collected from five locations for the studies listed above (Table 2-5 and Figure 2-12). In some cases, a location was sampled more than once, so more than 50 individual surface sediment samples are represented in the database. Nine of the surface sediment sample locations are within the impoundments, and an additional five are in their immediate vicinity. The highest spatial density of samples within the preliminary Site perimeter is in and adjacent to the impoundments and adjacent to the I-10 Bridge (Figures 2-12 and 2-13). Sediment samples collected within the Site upstream of the impoundments are approximately 1,000 feet (305 m) apart. Under or downstream of the I-10 Bridge, 25 samples were collected, but 16 of these are not within the preliminary Site perimeter and 15 are closely spaced around the Sneed Shipbuilding facility. Louchouarn and Brinkmeyer (2009) also collected samples for analysis of dioxins and furans and organic carbons (OC) in one surface grab sediment sample, and in one 1-m (3-foot) core from within the impoundments and sectioned at 2-cm (0.8-inch) intervals, but these data could not be accessed in time for this evaluation.

Surface sediment chemistry samples from 45 of the Site locations and all of the cores were collected in 2000 or later (Table 2-4). All of these samples were analyzed for dioxins and furans; metals and other chemicals were also analyzed in sediment from 17 surface and four subsurface locations within the Site, and in surface sediments at five locations nearby but outside the Site (Table 2-5). Data for pesticides, PCBs, and many SVOCs in surface sediments were generated by TCEQ and USEPA (2006), University of Houston and Parsons (2009), Koenig (2010, pers. comm.), and by Weston (2006) (Table 2-5). In most of these samples, none of these chemicals (other than dioxins, furans, and metals) were detected, with very few exceptions. PCBs were measured as Aroclors by Weston (2006) and as congeners by the TMDL program (University of Houston and Parsons 2009, and Koenig 2010 (pers. comm.). PCBs were not detected in any of the samples collected by Weston (2006), which were from the vicinity of the I-10 Bridge downstream of the impoundments. Individual congeners were detected in the sediment samples collected in 2002, 2003, 2008, and 2009 by the TMDL program at a location (station 11193) downstream of the impoundments and of the I-10 Bridge.

Upstream sediments in the San Jacinto River have likely influenced sediment conditions within the Site and can be expected to continue to influence them in the future[2]. Available sediment data for the area upstream of the Site indicates that there are dioxins and furans present in sediments upstream (University of Houston and Parsons 2006). TCEQ's TMDL data also indicated that the TEQ concentrations in the tidally influenced embayment upstream of the Site are higher than those further upstream in the freshwater portion of the river.

TCEQ has investigated several possible sources of dioxins in this upstream area (University of Houston and Parsons 2006), including a both city and county wastewater treatment facilities, and found dioxins in both sludges and wastewaters. In addition, in October 1994, two petroleum pipelines ruptured during a flood of the San Jacinto River, igniting a fire that impacted over 186 acres of riparian habitat and shoreline areas (http://www.fws.gov/southwest/es/contaminants/NRDAR/SiteInformation/Texas/SanJac.pdf). Therefore, upstream background areas near the Site do not reflect a pristine or natural condition. Nevertheless, measurements of regional background conditions in sediments from

[2] Methods for evaluation and modeling of sediment transport between the Site and areas upstream and downstream will be addressed in a Technical Memorandum on Fate and Transport Modeling, as discussed in Section 6.1.5. The memorandum will be submitted according to the schedule in Section 8.

the San Jacinto River estuary are relevant to interpreting data from the Site and selecting appropriate remedial actions, if required.

Sediment samples were also collected from 26 locations near the Site (two locations are not shown on Figures 2-12 and 2-13 because they are farther upstream than the extent of this map. All but two of these locations were sampled in 2000 or later (Table 2-4). All of these samples were analyzed for dioxins and furans. Metals and other chemicals were measured in five of them (Table 2-5). Finally, one data set was generated for USEPA et al. (2009), but it does not provide concentrations of individual dioxin and furan congeners. This data is not included in this discussion because toxicity equivalent (TEQ) concentrations were calculated using a 1989 toxicity equivalency factor (TEF) scheme, and the dioxin and furan congener data were not available in time for this evaluation. These samples were collected at a facility directly east of the Sneed Shipbuilding site (Orion 2009).

2.3.3 Groundwater

There are currently no chemistry data for groundwater collected from the Site.

2.3.4 Surface Water

Two studies have generated surface water chemistry data for the Site:

- Houston Ship Channel dioxin TMDL study (University of Houston and Parsons 2006)
- Samples collected by TCEQ in August 2009 (TCEQ 2009)

The TMDL study collected nine surface water samples from one location within the preliminary Site perimeter on six different dates from 2002 through 2004. Dissolved dioxins and furans were measured in these samples. TCEQ collected three surface water samples from two locations within the preliminary Site perimeter in 2009 (Figure 2-14). Total (unfiltered) dioxins and furans were measured in these samples.

Within the most recent data set (TCEQ 2009) only one of the seven dioxin congeners (2,3,7,8-TCDD) was detected in any water sample, and it was detected in all three of them. Seven of the 10 furan congeners in this data set were detected (Table 2-8). Concentrations of both 2,3,7,8-TCDD and TCDF (the furan congener present at highest concentration) were higher in water samples at location TCEQ2009_01 than in the sample in the eastern portion of the impoundment (Table 2-9). Based on the coordinates and the description in the field notes, location TCEQ2009_01 is on the vegetated portion of the impounded area rather than in the San Jacinto River.

Within the earlier data set (dissolved data during 2002 to 2004), octachlorodibenzo-*p*-dioxin was consistently detected and present at concentrations higher than all other dioxin and furan congeners. Tetra- and octachlorodibenzofuran were the only other congeners that were consistently detected.

Upstream water samples were collected from three locations during 2002 to 2004 by the TMDL study (Table 2-10, Figure 2-15). Upstream concentrations of dissolved 2,3,7,8-TCDD and TCDF during the 2002 to 2004 period were lower than those measured within the Site during the same time period, but equivalent in magnitude to the concentrations of total 2,3,7,8 -TCDD and TCDF measured in the impoundment in 2009 (Tables 2-9 and 2-10).

2.3.5 Air

There are currently no chemistry data for air samples collected from the Site; however, dioxin and furan data were collected in the Houston Ship Channel TMDL study (University of Houston and Parsons 2006).

As part of the TMDL study, an air monitoring program was implemented to assess dioxin and furan loading via ambient air the Houston area. A total of five air monitoring stations were used, representing differing ambient air conditions in the city (i.e., rural, semi-rural, urban, commercial, industrial). The program was conducted between September 2002 and May 2006, and consisted of monthly, bi-monthly and 11-month sampling events. The length of the study was required due to the ultra trace levels of dioxins and furans in ambient air. During the sampling period, data were collected using high volume samplers (ambient air), precipitation collectors fitted with resin columns (wet/dry and bulk deposition) and total suspended particulate samplers (particle size distribution). All samples were collected by University of Houston personnel. Table 2-11 summarizes the sampling events.

The ambient air, particle size distribution, and dry deposition samples were analyzed by USEPA Method TO-9A (1999) using high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) equipment. Resin columns were analyzed using USEPA Method 1613B (1994).

The TMDL study was conducted in accordance with the QAPP approved for that project. The air sampling data were subjected to quality control/quality assurance (QC/QA) assessment for accuracy, precision, reproducibility and completeness. Section 3.2.5 discusses the TMDL study air data quality and usability.

Air monitoring data from ambient, particle size distribution and atmospheric deposition are provided in Tables 2-5 to 2-10 in the TMDL report (University of Houston and Parsons 2006) and are summarized as:

- Ambient air
  - All dioxin and furan congeners were detected in ambient air samples, ranging from non detected to 1,718 femtograms (fg)/m^3
  - 2,3,7,8-TCDD was detected at concentrations up to 2 fg/m^3
  - The most elevated samples from the sampling location is in an industrial area
  - On an annual basis (September 2002 to August 2003), the annual mean concentration was found to be 12 +/- 8 fg Texas-TEQ/m^3
- Particle size distribution
  - Increased toxicity values were correlated with the smallest particle sizes
  - About 86 percent of the Texas-TEQ concentration was associated with particles less than 0.95 microns
- Atmospheric deposition
  - Dry deposition flux was measured between 1 and 4 picograms (pg) Texas-TEQ/m^2day
  - 2,3,7,8-TCDD was not detected in dry deposition samples
  - Wet deposition flux varied between 10 and 23 Texas-TEQ/m^2day
  - 2,3,7,8-TCDD contributed approximately 2 percent flux

  - Comparisons between wet and dry deposition data indicated precipitation removed "a relatively significant amount of atmospheric dioxins"
- Major findings of data analysis
  - Peak dioxin and furan concentrations in ambient air were observed in cold months (i.e., December to March)
  - Comparison of data from industrial settings and commercial/residential settings near major highways yielded no significant difference. Section 6.4.2 of University of Houston and Parsons (2006, p. 188) compares air quality between residential and industrial areas, and their finding suggest that "traffic is a potential significant source of dioxins in the Houston area."
  - Dioxin and furan concentrations were found to negatively correlate with ozone and relative humidity, and positively with NO_x

2.3.6 Biological Tissue

The studies or programs that have collected tissue chemistry data within the area of the Site include:

- Houston Ship Channel toxicity study (ENSR and EHA 1995)
- Houston Ship Channel dioxin TMDL study (University of Houston and Parsons 2006)
- Samples collected by TDSHS for the fish consumption advisory program (TDSHS 2007)

Some of these data were collected prior to 2000: (ENSR and EHA 1995). The data collected in 2002, 2003, and 2004 by the University of Houston and Parsons (2006) and in 2004 by TDSHS (2007) represent recent conditions. This subset of data includes two sampling locations within the Site boundary and three sampling locations within the nearby area upstream of the Site (Figure 2-15). All samples were analyzed as edible tissue. No analyses have been conducted on whole organisms. There are currently no tissue data within the nearby areas downstream of the Site.

Within the preliminary Site perimeter, TDSHS collected fillets from blue catfish, hybrid striped bass, red drum, spotted seatrout, and edible tissue from blue crab, from one location. These samples were analyzed for metals, dioxins and furans, VOCs, SVOCs, PCBs, and pesticides. Detection frequencies for these samples and summary statistics for analytes are shown in Table 2-12. In general, only inorganic analytes, dioxins and furans, and a few pesticides were detected in these samples. PCBs (as Aroclor 1260) were detected in only one sample (blue catfish fillet) from the Site.

From the three upstream sampling locations, the TMDL program collected edible tissue from blue catfish, hardhead catfish, shad, and blue crab between 2002 and 2004. Blue catfish and blue crab were collected throughout this period, shad were collected only in 2002, and hardhead catfish were collected only in 2004. These samples were analyzed for dioxins and furans, PCBs, and pesticides (PCBs and pesticides were measured only in 2002). Detection frequencies for these samples and analytes are shown in Table 2-13.

2.3.7 Other Studies

Studies summarized below provide Site-specific or regional information of potential use or importance in scoping the RI/FS.

2.3.7.1 Louchouarn and Brinkmeyer (2009)

The results from the first of a four phase study on dioxins in the Houston Ship Channel and Galveston Bay system are provided by Louchouarn and Brinkmeyer (2009). The objectives of Phase 1 included evaluating possible remobilization of contaminated particles from the Site impoundments to the Houston Ship Channel and calculating porewater concentrations (through the use of different partitioning models) to estimate the sorption capacity of sediments in the impoundment. To meet these objectives, a sediment core was collected in 2006 from the submerged section of the waste impoundments (i.e., eastern side of the impoundments). The sediments from the core and archived sediment samples (from previous sampling events) were analyzed for dioxins and furans, organic and black carbon, polycyclic aromatic hydrocarbons (PAHs), and lignin-derived oxidation by-products.

By comparing the dioxin and furan fingerprints in the core to the archived sediments collected elsewhere in the Houston Ship Channel and to reference area sediments, Louchouarn and Brinkmeyer (2009) concluded that remobilization of contaminated sediment was limited to areas within close proximity to the impoundments and that contaminated sediments from the Site have not been mobilized and distributed throughout the system. On the basis of estimated porewater concentrations, Louchouarn and Brinkmeyer (2009) also concluded that dioxins could bioaccumulate, and that affected biota could transport dioxins away from the Site. However, the report states that "all though this work is based on empirical sorption coefficients that are relevant to the environment of study, accurate porewater concentrations (and thus bioaccumulation potential) need to be measured directly before any meaningful risk assessment and remediation strategy are to be devised."

Louchouarn and Brinkmeyer (2009) stated that although there are relatively high total organic carbon (TOC) and black carbon contents in the waste impoundment sediments, the mass of dioxin and furan compounds seems to exceed the sorption capacity of the sediment TOC, according to the partitioning model used. Their partitioning models do not account for partitioning to other sediment components such as clays. In other parts of the Houston Ship Channel system, they estimate that TOC and black carbon contents in the sediment are sufficient to sorb the dioxins present.

Louchouarn and Brinkmeyer (2009) also address sediment remediation options and note that there has been no statistically significant reduction in sediment dioxin concentrations in areas that have been dredged. They conclude that in situ microbial remediation of dioxins in the Houston Ship Channel and Galveston Bay system would be preferable to other remedial alternatives (e.g., dredging), which would result in dispersal of dioxin-contaminated sediments throughout the system, stating: "[f]rom both fiscal and environmental perspectives, in situ microbial remediation of dioxins in the [Houston Ship Channel] and [Galveston Bay] is preferable to alternatives, including the removal of contaminated sediments to landfills…Moreover, dredging of highly contaminated areas, such as the San Jacinto Waste Pits, may result in rapid dispersal of dioxins throughout Galveston Bay." (pp. 5-6).

2.3.7.2 Houston Ship Channel Toxicity Study (ENSR and EHA 1995)

A study of contamination and toxicity in the Houston Ship Channel, with particular focus on side bays and tidal tributaries, was undertaken in the mid-1990s. The study was designed to address recommendations generated during an earlier USEPA study that focused largely on the main Houston Ship Channel. A detailed water, sediment, and fish and crab sampling strategy was employed to characterize chemical concentrations and toxicity in the Houston Ship Channel and its bays and tributaries, and the temporal variability in these parameters across summer low-flow, winter low-flow, and wet weather conditions. Samples were collected from stations located in the upper, middle, and lower portion of bays and tributaries, and from stations along the main Houston Ship Channel. Water samples were collected at a uniform depth of 1 m. Sediment grab samples were collected from the center of each channel and from two locations equidistant between each bank and the center of the channel. Duplicate water and sediment samples were collected to assess sampling variability.

Water and sediment samples were collected from 35 stations during summer low-flow conditions. Samples from a five-station subset were collected at two-month intervals to assess temporal variability in contaminant levels and toxicity. Following evaluation of temporal variability using the summer low flow data, water and sediment samples from a subset of 11 selected stations were collected during winter low flow conditions; fish and crabs were also collected from a six-station subset. To evaluate the effect of wet weather on chemical concentrations and toxicity, water and sediment samples from ten stations were collected following heavy rainfall. Each subset included stations in the Houston Ship Channel and stations in representative bays and tributaries. Additional water and sediment samples were collected from seven stations for focused evaluation of dioxins and furans. Fish, crab, water, and sediment samples were collected from one station within the preliminary Site perimeter, one station upstream of the Site, and one downstream of the Site.

Water (dissolved and particulate fractions), sediment, and edible tissues from fish and crabs were evaluated for levels of numerous contaminants, including metals, SVOCs and VOCs, pesticides, PCBs, and dioxins and furans. Observed contaminant levels were compared with standards, screening values, or other criteria to identify chemicals present at high concentrations. In addition, toxicity of water and sediment samples to invertebrate species was evaluated. Chemical analyses and toxicity tests were conducted according to standard methods using appropriate positive, negative, and/or reference controls.

In water, concentrations of most chemicals evaluated were not unacceptably high, and toxicity to invertebrates was observed in a small proportion of sediment and water samples.

One exception to this generalization was the relatively high total mercury in particulate matter from water samples collected during wet weather conditions. Phthalates, chloroform, trichloroethane, and copper were also detected at relatively elevated levels. Several pesticides, including DDD, DDT, and lindane, were elevated in summer low-flow samples from a small proportion of stations. Water samples from two stations were toxic to mysid shrimp (*Mysidopsis bahia*) over a 7-day exposure period, as evidenced by decreased survival; these stations were not among those on or near the Site. Decreased survival was not observed for inland silversides (*Menidia beryllina*), although growth was reduced in water samples from two different stations. The study did not explore the causes of the observed effects.

Similarly, contaminants evaluated in sediment samples were generally not elevated, with some exceptions, notably tributyltin, which was considered elevated in all sediment samples. Dioxins and furans, expressed as TEQs, in sediment were highly variable and ranged from 0.57 to 409 ng/kg. The highest calculated sediment TEQs occurred in samples from stations in the Houston Ship Channel downstream of a wastewater treatment facility and an industrial outfall. Survival of an amphipod crustacean (*Ampelisca abdita*) over a 10-day exposure period was lower in sediment samples from most stations collected during summer low-flow conditions; authors concluded that this effect was likely a consequence of anoxia. Decreased survival was noted in sediment samples from three stations during winter low-flow conditions. Mysid (*Mysidopsis bahia*) survival was reduced in sediment samples collected during both summer and winter low-flow conditions relative to controls. The sediments collected from on the Site during winter low-flow conditions showed toxicity to mysids.

Arsenic was elevated in edible fish tissue from three stations within the main Houston Ship Channel, but not in edible crab tissue. Catfish from two stations had elevated levels of Aroclor 1260 and chrysene. Dioxins and furans were detected in fish and crab samples from several stations: calculated TEQs for blue catfish ranged from 0.02 to 2.31 ng/kg, for hardhead catfish ranged from 2.51 to 5.01 ng/kg, and for crab ranged from 0.14 to 5.54 ng/kg. No fish or crab deformities definitively attributable to toxin exposure were noted upon macroscopic examination.

2.3.7.3 Frank et al. (2001)

Frank et al. (2001) evaluated concentrations of multiple persistent organic pollutants in waterbird eggs in the Galveston Bay area. Several chemicals considered persistent by the authors, including dioxins and furans and PCBs, had been detected in fish and other organisms in this area, prompting this analysis of their concentrations in birds and an evaluation of potential adverse effects on birds. In addition to several areas sampled within Galveston Bay, two reference areas were included for comparison of levels of chemicals in eggs and adverse health effects. Alexander Island was the sampling location closest to the Site.

Eggs were collected from three bird species: neotropic cormorants (n = 28 eggs from four sites; n = 18 eggs from two reference sites), black-crowned night herons (n = 9 eggs from one site), and great egrets (n = 7 eggs from one site). Eggs evaluated from the two reference areas were from cormorants only. The collected eggs were evaluated for concentrations of pesticides, dioxin-like and non dioxin-like PCBs, and dioxins and furans using GC/MS. Egg extracts were evaluated for aryl hydrocarbon receptor (AhR) activity relative to that of TCDD, using a bioassay with rat hepatoma cells expressing an AhR-luciferase construct. TEQs were calculated both by the sum of TEF-weighted congener concentrations for each individual chemical and also on the basis of relative AhR-activating activity and the two types of TEQ estimates were compared. However, the authors did not specify whether TEF for mammals or birds were used for the calculated TEQ. Eggs were also examined for developmental abnormalities.

Total PCB concentrations were significantly greater ($p<0.05$) in cormorant eggs from the Alexander Island and Vingt-et-un test areas relative to control area cormorant eggs and were present at levels that may have an adverse effect on reproduction. In contrast, total PCBs in cormorant eggs from the Smith Point and Rollover Pass test areas and in heron and egret eggs from the Alexander Island test area were not significantly elevated relative to reference area egg values. PCB-153, PCB-138, PCB-180, and PCB-118 were the most common congeners detected in eggs from all three species. Statistical evaluation to compare concentrations of individual congeners was not conducted.

DDE and hexachlorobenzene (HCB) were detected in eggs from all three species in the test areas and in cormorant eggs from the reference areas. HCB was significantly elevated in cormorant eggs from Alexander Island relative to either reference area. DDE was not significantly elevated in eggs from any species or test area relative to either reference area. HCB, DDE, and total PCBs were greater in cormorant eggs from Alexander Island relative to heron and egret eggs from the same area, which are attributed by the authors to differences in diet.

Dioxin and furan, non-*ortho*-PCB, and mono-*ortho*-PCB congener concentrations were evaluated in a subset of the originally collected eggs, consisting of a total of eight cormorant eggs from three test areas, one reference cormorant egg, three test heron eggs, and three test egret eggs. Extracts from these eggs were also evaluated for AhR-activating activity using the rat hepatoma cell luciferase assay. TCDD was detected in all eggs except for the reference cormorant egg; the range was 7 to 179 pg/g wet weight. Two additional dioxin congeners, PeCDD and HxCDD, were detected in one test heron egg at concentrations of 25 and 26 pg/g wet weight, respectively. TCDF was detected in all three test heron eggs but not in cormorant or egret eggs; TCDF concentrations ranged from 6 to 12 pg/g wet weight. TCDD concentrations observed in heron and cormorant eggs were below the concentration considered by the authors to be the threshold of adverse effects in birds. However, since there are marked species differences in susceptibility to TCDD, the potential impact of these TCDD concentrations is uncertain.

In general, non-*ortho*- and mono-*ortho* PCB congeners were present in test area eggs in much greater concentrations than TCDD (3 to 4 orders of magnitude difference). Of the non-*ortho* (i.e., dioxin-like) congeners, PCB-126 was present at the highest concentration in eggs from all three species. Instrumental TEQs calculated by congener concentration analysis were in general about 30 percent greater than those obtained through the rat hepatoma cell luciferase assay, suggesting that *in vitro* activities of tissue extracts may be less than predicted by calculation of potential AhR activity using TEFs. Calculated TEQs were significantly correlated with TEQ activity measured by the bioassay. Instrumental TEQs from test area birds ranged from 136 to 452 pg/g compared to a TEQ of 67 pg/g for the single reference area cormorant egg. PCB-126 contributed the most to total calculated TEQs: PCB-126 contributed from 46 to 91 percent of the TEQ in eggs, while TCDD contributed 26 to 51 percent of calculated TEQs. The authors concluded that PCB-126 presents a greater threat to wildlife than TCDD.

2.3.7.4 Dean et al. (2009)

This study presents investigations of the relationship of dioxins and furans in water and sediment to concentrations in catfish and crab tissue using structural equation modeling (SEM) based on the assumptions of equilibrium partitioning (EqP) theory. The data used were generated by the TCEQ TMDL program and are among those data summarized in Section 2.3.2. Samples of hardhead catfish (*Ariopsis felis* L.) fillet and blue crab (*Callinectes sapidus* Rathbun) edible tissue were collected at 45 locations throughout the Houston Ship Channel from 2002 to 2004 during spring, summer, and fall. Surface sediment (0 to 5 cm) grab samples and high volume water samples were also collected at the same sites, resulting in a total of 108 synoptic hardhead catfish, sediment, and water samples, and 155 synoptic samples of each medium with blue crab. All analyses in this study were performed using tissue and sediment (and/or water) samples uniquely paired by location and date. The authors discuss the uncertainties and limitations of this approach (pairing mobile organisms to point samples of sediment and water chemistry), recognizing that grab samples of sediment and water from fixed locations may not accurately reflect exposures of mobile organisms, which is likely variable in both space and time.

Bioaccumulation factors (BAFs) and biota–sediment accumulation factors (BSAFs) were calculated as the median of the ratios of lipid-normalized tissue to water and sediment concentrations, respectively. The authors acknowledge the weaknesses of this approach, particularly because dioxin and furan concentrations in tissue were found to be only weakly correlated to lipid levels. They also acknowledge that the use of lipid normalization may be inappropriate. The values of log BAFs for individual congeners varied from 4.41 to 7.03, while those for log BSAF were all negative (–3.19 to –0.41). Given these results, the authors propose that metabolism limits the bioaccumulation of furans in both hardhead catfish and blue crab.

Dean et al. (2009) used SEM as an alternative to BAFs and BSAFs to investigate potential drivers of dioxin and furan tissue loads in addition to water and sediment concentrations.

Other parameters explored in the SEM analysis were sediment TOC, tissue lipid content, seasonality, air temperature, fish length, and weight. The results of SEM suggested that sediment chemistry contributed slightly more explanatory power than water to the overall fraction of variance of tissue concentrations explained by each model. The authors concluded that a large percentage (40 to 88 percent) of variation in bioaccumulation remains unexplained by the data and methods they used, and hypothesized that biotransformation may be the driving process governing concentrations of dioxins and furans in fish and crab tissue.

2.3.7.5 Fish Consumption Advisories

TDSHS routinely samples edible tissues of fish and crabs from several locations in Galveston Bay and the Houston Ship Channel vicinity. The agency has published several reports that provide both chemical data for edible fish and crab tissue, and an evaluation of human health risks, which provides the basis for their advisories. Related to these reports, three fish and shellfish consumption advisories have been issued by TDSHS that cover waters within the Site boundaries. Once issued, TDSHS advisories are periodically reevaluated based on new monitoring data. A chronological summary of the advisories, reevaluations, and associated risk characterization reports applicable to Site waters is provided in Table 2-14, and is summarized below.

The first advisory for this area, ADV-3 (TDH 1990), was issued in 1990 based on concerns over dioxins in catfish and blue crabs. This advisory was re-evaluated in subsequent years based on new monitoring data and continues to be in effect today. In addition, in 2001, ADV-3 was augmented by a new advisory, ADV-20 (TDH 2001b), also covering waters within the Site. ADV-20 addressed health concerns related to consumption of all species of finfish due to the presence of elevated concentrations of pesticides and PCBs. Both advisories recommend that adults eat no more than one 8-ounce meal each month from the advisory area and suggest that women of childbearing age and children not consume catfish or blue crabs from the advisory areas. In 2005, an additional advisory, ADV-28 (TDSHS 2005b), was issued for spotted seatrout from these waters due to concerns about PCBs, pesticides, and dioxins. This advisory recommends that adults limit consumption of spotted seatrout from the advisory area to no more than one 8-ounce meal per month and that women who are nursing, pregnant, or may become pregnant, and children should not consume spotted seatrout from these waters.

2.3.7.6 Summary

Several reports providing Site-related data and interpretation in addition to the raw data available in the database are available and provide information useful to scoping the RI/FS. Conclusions and information derived from these studies include the following:

- Sediments collected from within the impoundments were contaminated with dioxins and furans, and the fingerprint of the mixture was distinct from those in sediments collected from elsewhere in the Houston Ship Channel, including stations fairly nearby and downstream. On the basis of initial fingerprinting and comparisons with dioxin and furan fingerprints at other stations, the authors conclude that "the remobilization of contaminated particles does not occur beyond the close vicinity of the pit itself" (Louchouarn and Brinkmeyer 2009, page 12). The sediments in the impoundments also contained relatively high TOC, which binds dioxins and furans, but the TOC is not sufficient to bind all the mass of the dioxin and furans in the sediments from the impoundments (Louchouarn and Brinkmeyer 2009).
- Eggs of wading and diving piscivorous birds from the Galveston Bay area are contaminated with several industrial chemicals, including pesticides, PCBs, and dioxins and furans, to levels greater than those in eggs from reference areas. PCBs contribute the greatest fraction of dioxin-like toxicity in sampled bird eggs. Comparisons between calculated TEQs and those estimated using a rat hepatoma cell assay differ by 30 percent, indicating that TEQs calculated using TEFs may overestimate the actual AhR activating potential of the chemical extracts from the eggs (Frank et al. 2001).
- Although not specifically focused on dioxin and furans, toxicity of water and sediments from throughout the Houston Ship Channel in the early 1990s was low, but was variable over time, and was greatest in summer low-flow periods. Sediments and water collected near the Site were not the most contaminated, nor the most toxic in the study (ENSR and EHA 1995).
- Available data for sediment and water chemistry from the TMDL program, and the SEM used by the authors, can be used to explain some of the variation in

bioaccumulation of dioxins and furans in edible fish and crab tissues, but much of the variation remains unexplained by environmental parameters suggesting that metabolic processes play an important role in determining tissue residues of fish and crabs. Simple congener-specific BAFs and BSAFs vary over several orders of magnitude (Dean et al. 2009).

- Elevated concentration of chemicals including pesticides, PCBs, and dioxins and furans in fish and crab tissues collected near the Site as part of the TDSHS consumption advisory program have resulted in consumption advisories in the area near the Site including an advisory to avoid consumption of catfish and crabs, due to dioxin and furan contamination that has been in place since 1990. Fish consumption advisories have also been in place and are driven by concentrations of PCBs in fish tissue. In describing the relative importance of PCBs and other chemicals in the risk assessment performed by the TDSHS (2005), the conclusions state that "in the past, dioxins have been prevalent contaminants of catfish and blue crabs, yet in the present data set dioxin contributes only modestly to the toxicity associated with consumption of blue crabs and catfish from the HSC or Upper Galveston Bay" (TDSHS 2005b).

2.4 Demographics and Human Site Use Information

As described in Section 2.2.3, current land use surrounding the Site includes mixed residential and industrial to the west of the Site and undeveloped or residential areas to the east and north of the Site. Immediately south of the Site is commercial/industrial land use; further south is the river. According to the U.S. Census Bureau,[3] the estimated population of Harris County was 3,984,349 people in 2008, with 8.8 percent of the population under 5 years of age, 28.7 percent under age 18, and 7.9 percent over 65 years old. Of the population age 5 years and older, an estimated 47.8 percent were living in the same house in 1995 and in 2000. A summary of local demographics is provided in this section.

TDSHS reports that the San Jacinto River along with nearby Upper Galveston Bay, Tabbs Bay, and the San Jacinto State Park have "many points of public access and support both recreational and subsistence fishing activities" (TDSHS 2005a). However, published information on the intensity and types of recreational activities as well as fish and shellfish harvesting activities within the immediate vicinity of the Site is limited, with only data

[3] http://quickfacts.census.gov/qfd/states/48/48201.html

consisting of general creel surveys for the greater Houston area by the Texas Department of Parks and Wildlife. A summary of available information on these and other Site uses is discussed below.

2.4.1 Demographics

Based on the 2007 census estimate, the City of Houston is the fourth largest city in the United States (USCB 2007). In 2009, the City of Houston Planning and Development Department estimated that Houston had a population of 2.2 million (CHPDD 2010). According to the 2000 census, the racial makeup of the city was a mixture of Caucasian, Hispanic, African American, and Asian. The city has the third-largest Hispanic and Vietnamese American populations in the United States (CHPDD 2009; Carter 2004). Houston has the fourth highest foreign born population in the United Sates (CHPDD 2009) at 28 percent. In nine years (i.e., from 2000 to 2009), the Hispanic population in Houston increased from 37 to 42 percent (CHPDD 2009). The Hispanic population in Houston is increasing as more immigrants from Latin American countries look for work in the area. It is estimated that about 400,000 immigrants reside in the Houston area illegally (Hegstrom 2006).

In 2007, the median household income in Houston was approximately $40,000 per year, which was below the national median household income level in the United States ($50,000) (USCB 2007). Approximately 22 percent of individuals and 18 percent of families living in Houston are living below the poverty line (USCB 2007). In addition, 33 percent of people that are 16 years and older living in Houston are unemployed (CHPDD 2009).
The Site is located in Channelview, a suburb of Houston (TSHA 1999). According to the 2006 census (USCB 2006), the population of Channelview is approximately 40,000; this represents an increase of 26 percent in the population over a 6-year period. The racial makeup of Channelview is very similar to that of Houston; however, the percentage of Hispanics in Channelview is greater (approximately 54 percent). The median household income in Channelview is slightly higher than Houston (i.e., $43,000 per year) and fewer individuals and families in Channelview are living below the poverty line (approximately 14 percent and 12 percent, respectively).

2.4.2 Harvesting Shellfish and Fish

Throughout Galveston Bay, the commercial and recreational fishing industries are substantial. Within the Site boundaries, fishing is known to occur, but the amount and frequency of fishing has not been determined.

Consumption of molluscan shellfish (clams, mussels, and oysters) taken from public fresh waters is prohibited by TDSHS. Within public salt waters, these shellfish may be taken only from waters approved by TDSHS. TDSHS shellfish harvest maps[4] designate approved or conditionally approved harvest areas. Waters within the Site boundaries are not included on these maps (TPWD 2009).

Despite current fish and crab consumption advisories (Section 2.3.7.5), fishing activity within the waters of the Site have been observed and fishers in this area are reported to collect whatever they catch (Beauchamp 2010, pers. comm.). Specifically, along the northeast side of the tip of the impoundment area, fishing is reported to be popular and people have been observed to wade out in the water on the east side, fishing and using crab cages in this area. Fishing has also been observed to occur under the I-10 Bridge, especially during warmer weather due to the shade, as well as to the south. Constraints on accessibility to the industrial area south of I-10 and to Hog Island to the south (where land consists largely of submerged sand bars) limits fishing activity in these areas (Beauchamp 2010, pers. comm.). Other points of fishing access within the Site include RV trailer parks on the east side of the river north of I-10 with access to the river and a public access area with a boat ramp at Meadowbrook Park west of the Site boundary (Beauchamp 2010, pers. comm.).

2.4.3 Other Recreational Activities

Although the lands within the Site are private, points of access available to the public occur along and within the Site boundaries and allow for a wide variety of recreational activities at the Site including picnicking, swimming, nature walks, bird watching, wading, fishing, boating, and water sports. Shoreline use and wading with the Site has been observed (Beauchamp 2010, pers. comm.). In the area to the south of the bridge, on the west side of

[4] http://www.dshs.state.tx.us/seafood/classification.shtm#maps

the river, children and adults have been reported playing along the shoreline and wading in the water, as well as fishing.

2.4.4 Potable Use of Surface Water from the Site

There are no surface water intakes within 15 miles downstream of the impoundments (TCEQ and USEPA 2006).

2.5 Ecological Resources

The Site is located in a low-gradient, tidally influenced area. Open channel, sandy shorelines, and estuarine and marine fringing wetlands are among the habitats in the lower San Jacinto River that provide feeding and nesting grounds for a variety of fish, reptiles, birds, and mammals. The habitats found at the Site and biota that could be associated with the Site is discussed in this section. Additional details are provided in Appendix B and Attachment B1.

2.5.1 Habitats

Wildlife habitats on the northern portion of the Site include shallow and deep estuarine waters, and shoreline areas occupied by estuarine riparian vegetation. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2-17). Minimal habitat is present in the upland terrestrial area of the Site west of the impoundments, as sand sorting activities created a denuded upland area with a covering of crushed cement and sand. The sandy shoreline of this area is littered with riprap, other metal debris and piles of cement fragments. Estuarine riparian vegetation lines the upland area that runs parallel to I-10. To the west of the central berm within the impounded area, the area is currently occupied by late successional stage vegetation, and to the east the historically impounded area is consistently submerged even at low tide.

Surface waters in the vicinity of the Site are low in salinity (1 to 5 ppt; Clark et al. 1999), and the in-water portion of the Site is primarily unvegetated with a deep (20 to 30 foot) central channel and shallow (3 feet or less) sides (NOAA 1995; Clark et al. 1999). Sediments are characterized by low organic matter content (0.2 to 3 percent in sediments sampled in the river channel adjacent to the impoundments by the TMDL study [University of Houston and

Parsons 2006]) and high sand content (22 to 42 percent sand in a sediment sample collected adjacent to the Site [ENSR and EHA 1995]).

The tidal portions of the San Jacinto River and Galveston Bay provide rearing, spawning, and adult habitat for marine and estuarine fish and invertebrate species including blue crab, drum, flounder, spot, spotted sea trout, and shrimp (Gardiner et al. 2008; Usenko et al. 2009). An estimated 34 acres of estuarine and marine wetlands are found within the Site perimeter. Throughout the broader area there are approximately 55 additional acres of freshwater, estuarine, and marine wetlands (Figure 2-17).

2.5.2 Benthic Macroinvertebrates

Species making up the benthic macroinvertebrate community spend all of most of their life cycles living in or on the sediment, often in highly localized areas. In addition, these organisms are prey for a variety of benthivorous fish and wildlife species. Benthic macroinvertebrates known to occur in the vicinity of the Site include crabs, shrimp, oysters, and clams (Broach 2010; GBIC 2010); blue crabs have been collected from the river channel adjacent to the impoundments (University of Houston and Parsons 2006). In addition, smaller species adapted to the low-salinity conditions, such as euryhaline polychaetes, oligochaetes, and amphipods, may be expected in the vicinity of the Site.

2.5.3 Fish

The fish community at the Site includes a variety of euryhaline species with various feeding strategies, including omnivores, invertivores, and piscivores. Fish species that have been listed in association with or collected from the tidal portion of the lower San Jacinto River include hardhead and blue catfish, drum, spotted sea trout, and flounder (Osborn et al. 1992; University of Houston and Parsons 2006; Gardiner et al. 2008). A list of fish species that have been collected in the vicinity of the Site or that could be expected at the Site given their distribution and habitat preferences is provided in Attachment B1 to the SLERA (Appendix B).

2.5.4 Reptiles and Amphibians

Reptiles that may be found at the Site include alligators, snakes, and turtles (Attachment B1 of Appendix B). Snapping turtles, sliders, softshells, and terrapins are among the turtle species that have been described as associated with the Trinity River National Wildlife Refuge (USFWS 2009), which is located on the other major tributary to Galveston Bay, to the northeast of the San Jacinto River. None of the amphibians that are potentially present in the region are tolerant of brackish or saline waters, with the possible exception of the southern leopard frog, so amphibians are not expected to be found at the Site.

2.5.5 Birds

A wide variety of birds, including raptors, herons, rails, pelicans, gulls, ducks, and sandpipers, use the types of habitats that are present in the vicinity of the Site (Attachment B1 to Appendix B). Dabbling ducks including gadwall and teal may winter in the vicinity of the Site. Sandpipers, egrets, and herons are wading birds that forage along shallow intertidal areas for benthic infauna, small fish, and crustaceans. Piscivores foraging in the open waters of the river include cormorants, osprey, and pelicans. Omnivores including gulls and ducks may forage at the river's edge, as well as in the water column and in the shallow benthos.

2.5.6 Mammals

The number of mammalian species that feed on aquatic prey that may potentially occur within the Site is limited. Nutria and muskrat may be expected in the vicinity in wetland areas with emergent vegetation and otter may use or move through the area while foraging for prey. Marsh rice rats may use riparian and aquatic habitats. Although mink may be present in other parts of the Galveston Bay system, the type of habitat characterizing the Site is not considered appropriate for mink. Mink prefer wetland habitats with abundant cover such as shrubby or dense vegetation and well-developed riparian zones, prefer small streams to large, broad rivers, and avoid exposed or open areas of the type that characterize the shorelines of the Site (Allen 1984). Additional mammal species, including skunk, opossum and raccoon, may use riparian areas adjacent to the river for foraging and corridors for moving across territories (Attachment B1 to Appendix B).

2.6 Cultural Resources

This section provides a description of the Site's cultural resource features and a synopsis of Site History. The USEPA is required to comply with Section 106 of the National Historic Preservation Act (NHPA) and its implementing regulations at 36 CFR 800 as part of the RI/FS activities and eventual Site Remediation strategy. This section assists the USEPA in compliance by providing a synopsis of whether National Register of Historic Places (NRHP) eligible historic properties are present in the preliminary areas of concern.

The preliminary areas of concern include all areas that could be directly and indirectly affected by remedial actions that may be required for the Site (36 CFR 800.16[d]). It is assumed that the RI/FS activities and Site remediation will not involve demolition or modification of existing buildings, bridges, or other structures. Therefore, it is not likely that those activities will affect the built environment, and the preliminary area of concern will be restricted to ground disturbance that could potentially affect archaeological deposits.

2.6.1 Historical Context

The archaeology of coastal Texas is not as well known as it is in other parts of the state. According to Ricklis (2004), "the poor understanding of areal chronology is matched by a general lack of insight into synchronic patterns of prehistoric resource use and settlement patterns." In general, though, the earliest occupation is thought to be Paleoindian. The Paleoindian period dates from around 12,000 Before Present (B.P.) to 8,000 B.P., though no dated sites are found in the coastal region (Ricklis 2004). The subsequent Archaic period lasted from 8,000 B.P. to 1,200 B.P. is characterized by adaptation to a drier climate, increase in the diversity of projectile points, and widespread trade networks. The Late Prehistoric period follows the archaic, and is "in large part, if not entirely, the archaeological correlate of the ethnically and linguistically distinct Karankawa groups" (Ricklis 2004).

In the historic era, the San Jacinto River area was the traditional homeland of Capoque or Cocos band of the Karankawa Indians, a group of at least 400 people (Himmel 1999). The Karankawa were nomadic people who hunted, fished and gathered and performed a rich ceremonial cycle. They traveled in dugout canoes between temporary campsites, made pottery, baskets, and red cedar bows; and lived in shelters made of willow poles and rush mats (Lipscomb 2002). The Karankawa are now extinct as a tribal group. After decades of conflict with Euroamerican settlers, the last remaining group of Karankawas was annihilated in 1858 (Lipscomb 2002).

Although Spain claimed the area that is now Harris County in 1528, few Euroamericans visited the San Jacinto River area until the early 1700s when French traders from the New Orleans area headed west (Henson 2002; Jackson 2002). A 1718 map by Guillaume Delisle shows the San Jacinto area labeled "Wild and Cannibalistic Indians" (Figure 2-18). The San Jacinto River was "a zone of perennial dispute between rival Spanish and French colonial empires," and the Spanish extensively explored the area in the mid 1700s (Jackson 2002). For the next hundred years, settlements were sparse, and mostly related to military concern, due at least in part to the difficultly of travel along shallow rivers and marshy uplands (Himmel 1999). The nearest settlement to the project area was the Spanish fort El Orcoquisac, about 20 miles east on the Trinity River (Ladd 2002).

In 1821 "American Indian groups occupied all of Texas" (Himmel 1999). One year later, a group of American settlers arrived in the San Jacinto area, and over the next ten years the Euroamerican settlement increased while the Native American population declined (Henson 2002). The mostly American settlers in Texas soon came into conflict with the Mexican government, leading to the Texas Revolution.

The Revolution's Battle of San Jacinto took place approximately three miles south-southwest of the impoundments on April 21, 1836, and was "the deciding moment in the Texas Revolution" (Moore 2004). About six weeks earlier, a Texan force had been defeated at the Alamo by Mexican soldiers under General Antonio Lopez de Santa Anna (Nofi 1992). Santa Anna's soldiers pursued Texan soldiers under the command of General Sam Houston, and the two armies met just south of where Buffalo Bayou enters the San Jacinto River, on a farm owned by a widow (Henson 2002). The Texas army overcame the Mexicans in under 20 minutes, ultimately killing as many as 900 Mexican soldiers (Moore 2004). Although no part of the battle took place at or near the impoundments, Houston's soldiers may have transited the area as they crossed at Lynch's Ferry at the former town of Lynchburg on the east bank of the river south of I-10 (Moore 2004). General Santa Anna retreated from Texas in 1837, and Mexico recognized Texan independence in 1848 (Griswold del Castillo 1990).

Harris County recovered from the revolution slowly. By 1853 it had a steam mill and was the terminus for the Buffalo Bayou, Brazos, and Colorado Railway, which crossed the county to Stafford's Point to facilitate the shipment of cotton and sugar. Five other railroads followed before the Civil War (Henson 2002). Settlers before the Civil War arrived mostly from the southeastern United States, many bringing African-American slaves while settlers after the Civil War included many Midwesterners (Henson 2002).

The area around the San Jacinto River was primarily rural and agricultural for nearly another century. An aerial photo from 1944 (Figure 2-19) shows the river meandering past a small rural settlement on the east bank, with a state highway crossing near Lynch's Ferry. The new I-10 Bridge is visible in a 1957 aerial photo (Figure 2-20) and a 1967 topographic map documents increasing population density (Figure 2-21).

2.6.2 Previous Research

There are no recorded archaeological sites in the preliminary area of concern, and no part of the preliminary area of concern has been previously archaeologically surveyed. Within a mile of the preliminary areas of concern, five sites are recorded (Table 2-15). Descriptions are from the Texas Historical Commission TARL Site Forms.

Table 2-15
Recorded Archaeological Sites

Site Number	Description	Distance from Impoundments
41HR15	"Earthen mound and lithic scatter" on "old river terrace."	0.9 miles (1.5 km)
41HR27	San Jacinto Site 1. Apparently a precontact site. Currently entirely submerged.	1.0 miles (1.6 km)
41HR28	Precontact shell midden. Currently entirely submerged.	1,500 feet (450 m)
41HR407	Historic archaeological site, dates to mid-19th century. Homesite and sawmill, possible slave quarters.	1.0 miles (1.6 km)
41HR724	Scattered redeposited shell, likely not in situ. Currently entirely submerged.	2,000 feet (630 m)

Table 2-16
Archaeological Surveys

Author	Date	Title	Sites Visited within 1 mile of Impoundments
Hudson, Kay G.	1991	Archaeological Survey, Houston International Terminal, San Jacinto River, Harris County, Texas.	41HR28
McClure, W. and Leland W. Patterson	1975	Prehistoric Occupation of White Oak Bayou Watershed.	41HR15
Moore, Roger G. and Robert Travis	1994	Cultural Resources Investigations and Coordination for the San Jacinto Oil Spill Incident, Harris County, Texas	None
Carlson, Shawn Bonath	1998	Archaeological Investigations at the David G. Burnet Park (41HR407), Harris County, Texas	41HR407

The three in situ pre-contact sites (41HR15, 41HR27, and 41HR28) and the historic site (41HR407) all clearly represent occupations of the riverbank immediately adjacent to the river prior to historic and modern subsidence. Given this settlement pattern, the preliminary area of concern would have had a high probability for archaeological resources at or near the original ground surface. Industrial activities at the Site and the associated subsidence and erosion, have reduced the archaeological potential. Given the deltaic depositional environment, deeply buried sites may be present. However, meandering and repeated flooding in the pre-contact era may have also eroded such sites in the past.

2.6.3 Recommendations

No NRHP-eligible properties are documented in the area if concern. Because of the extensive disturbance to the Site and minimal ground disturbance that will likely occur for the project, it is not likely that NRHP-eligible historic properties will be affected by RI/FS or eventual Site remediation activities. A final determination on the potential effect of Site remediation activities on NRHP-eligible historic properties may be required as part of the Site FS after potential Site remediation and management strategies are better understood.

3 ASSESSMENT OF DATA QUALITY AND USABILITY

Data quality reviews were performed for compiled historical sediment chemistry, water chemistry, and tissue chemistry data. The reviews were performed prior to entering the historical data into the project database. The purpose of this review was to fully evaluate each data set and categorize the quality of the data in the database, ensuring that these data are used for appropriate purposes throughout the RI/FS process. Data quality categories are defined as follows:

- Category 1 data are of known quality and are considered to be acceptable for use in decision making for the Site. There is sufficient information on these data sets to confidently verify that the data, along with associated data qualifiers, accurately represent chemical concentrations present at the time of sampling.
- Category 2 data are of generally unknown or suspect quality. The QA/QC information shows that data quality is poor or suspect, or essential QA/QC data (e.g., surrogate recoveries, matrix spike/matrix spike duplicates) are either incomplete or do not exist.

This evaluation focused on individual analyte groups within each survey when possible. Thus a specific survey may contain all Category 1 data, all Category 2 data, or a combination of Category 1 and 2 data. In addition, data that received a Stage 1, 2A, 2B, 3, or 4 level of validation (as defined in Table 3-1) were flagged as such, providing a combined data quality category (e.g., Category 1 Stage 2B). Some data sets have been loaded into the data base and are noted as Category 2 because QA/QC information was not fully available at the time the data were loaded. As a result, Category 2 data may be classified as such simply because QA/QC information was not readily available. These data may subsequently be considered Category 1 if in-depth QA is performed, and the data are found to warrant this classification. Additional QA review of Category 2 data will be limited to those data sets deemed of importance to the RI/FS process and decisions.

3.1 Chemical Data Review Criteria

Criteria for placing data sets into categories were developed during the compilation of existing information to identify basic data qualities, not to limit data to specific program uses. Chemical data quality was assessed by evaluating the following factors:

- Traceability
- Comparability
- Sample integrity
- Potential measurement bias (i.e., accuracy, precision)

All of these factors were known or supported by existing QA/QC information (e.g., analytical methods, chain-of-custody, sample holding time, method blanks, matrix spike/matrix spike duplicates, laboratory control samples, replicates, surrogates) for Category 1 data. If supporting documentation for each factor was not available or was not reinforced by the availability of other high quality QA/QC information, data were assigned a Category 2 designation. If the acceptance criteria for any of the above factors were not satisfied for either the entire data set or a specific analyte group, data for that data set or group were generally qualified and were determined to have limited usefulness (e.g., appropriate for limited tasks such as determination of COPCs). The chemical data were reviewed by analyte group (e.g., metals, dioxins and furans, PCBs). As a result, a data set may contain all Category 1 data, all Category 2 data, or both Category 1 and Category 2.

3.2 Data Quality Assessment Results

Data quality reviews were completed for all historical data incorporated into the San Jacinto database. Data quality assessment results are summarized in Table 3-2, with details provided below.

3.2.1 Soil

There are currently no chemistry data for soils collected from the Site.

3.2.2 Sediment

Data quality reviews were completed for ten data sets, and results are provided in Appendix D-1. Two of the ten sediment surveys received a Category 1 designation, with the remaining surveys receiving a Category 2 designation. In general, insufficient QA/QC documentation was available for the eight sediment chemistry data sets to receive a Category 1 designation.

3.2.3 Groundwater

There are currently no chemistry data for groundwater collected from the Site.

3.2.4 Surface Water

Data quality reviews were completed for two data sets, and results are provided in Appendix D-2. One data set was assigned to Category 2, and the other data set was classified as Category 1. As for most of the sediment data, insufficient QA/QC documentation was available for the surface water chemistry data set classified as Category 2.

3.2.5 Air

There are currently no chemistry data for air collected from the Site. However, data quality review was completed for a TMDL study conducted within the Houston Ship Channel region and results are provided in Appendix D-3. All air quality data associated with this TMDL study were assigned to Category 2. In general, insufficient QA/AC documentation was available for the air chemistry data set.

3.2.6 Biological Tissue

Data quality reviews were completed for two data sets, and results are provided in Appendix D-4. All tissue data sets were assigned to Category 2. In general, insufficient QA/QC documentation was available for the tissue chemistry data sets.

3.3 Database Entry Quality Assurance

After the data quality assessment was completed and data were incorporated into the database, a standard database QA review was performed in which 100 percent of the results from 10 percent of the samples entered into the database were compared to the source files and reports. If errors were discovered for a given subset of the data (e.g., analyte group), that subset was then subjected to a 100 percent review before integration into the Site geodatabase. The Site geodatabase will serve as the source compendium for all environmental data.

4 CONCEPTUAL SITE MODEL

Understanding the major physical and chemical processes that control the distribution and concentrations of COPCs at the Site is gained through the development and refinement (based on the iterative evaluation of Site-specific information) of a CSM. A CSM for a contaminated Site provides a succinct depiction of the sources of contaminants, the physical-chemical processes that control chemical transport and fate over time and space, and the exposure pathways that potentially lead to exposure and adverse effects to ecological and human receptors. CSMs are a key component of the RI/FS process because they illustrate the links between Site investigation data and the assessment of risk (ASTM 1995). CSMs also establish a context for evaluating potential Site-associated sources and risk versus non Site-associated sources and risk.

Figure 4-1 is a general CSM pathway diagram for the Site showing the major sources, release mechanisms/transport pathways, exposure media, and potential human and ecological receptors of concern. This CSM is focused on the characteristics of the primary COPCs and indicator chemical group at the Site; dioxins and furans. General chemical characteristics of the other primary COPCs identified for the Site (several metals and bis-2(ethylhexyl) phthalate) are presented in Appendix E.[5]

This section is divided into three sub-sections. The physical and chemical elements of the CSM are described in Section 4.1, which is divided into four parts. Section 4.1.1 provides an overview of dioxin and furan chemical properties and behavior in the environment. Section 4.1.2 describes how the cumulative toxicity of exposure to combinations of several dioxin and furan congeners together is addressed for birds, mammals and fish. Section 4.1.3 details the dioxin and furan sources, release mechanisms, and transport processes associated with the Site, and Section 4.1.4 discusses regional and global dioxin and furan sources, release mechanisms, and transport processes. Sections 4.2 and 4.3 then discuss potential receptors of concern and exposure pathways for human an ecological receptors, respectively.

[5] Secondary COPCs will be addressed in revised project CSM descriptions if it is determined that they need to be evaluated in the baseline risk assessments.

4.1 Dioxin and Furan Chemistry, Sources, Release Mechanisms, and Transport Pathways

Following an overview of general dioxin and furan chemical behavior in the environment and the means to evaluate dioxin and furan exposure and toxicity, this section details the current understanding of the sources, release mechanisms, and transport and fate processes at the Site. Figure 4-2 illustrates some of the major physical and chemical fate and transport processes discussed below.

4.1.1 Dioxin and Furan Chemical Properties and Behavior in the Environment

Dioxins and furans are a family of polychlorinated organic chemicals with similar chemical structures. They are characterized by extremely low vapor pressures, high octanol-water and organic carbon partitioning coefficients (Kow and Koc, respectively), and extremely low water solubilities. These factors indicate a strong affinity for sediments, particularly sediments with high organic content, and for lipids within biological tissue. Although some dioxins deposited on or near the water surface will be broken down by sunlight, and a very small portion will evaporate to air, the vast majority will sorb strongly to particulate matter, including organic matter, and eventually settle to the sediment bed, where they will be subject to sediment transport processes. After they are sorbed to particulate matter or bound in the sediment organic phase, they exhibit little potential for leaching or volatilization. They are highly stable in abiotic environmental media, with persistence typically measured in decades. An environmentally significant transformation process for dioxin congeners is believed to be photodegradation of chemicals not bound to particles in the gaseous phase or at the soil-air or water-air interface (USEPA 1994).

Chemical degradation of dioxins and furans through reductive chlorination can also occur. Recent research in the San Jacinto estuary found widespread occurrence of known dioxin-degrading bacteria, *Dehalococcoides* spp., in sediments throughout the Houston Ship Channel and Galveston Bay (Louchouarn and Brinkmeyer 2009). These bacteria use polychlorinated compounds as electron acceptors in the anaerobic process of de-halorespiration (Bunge et al. 2003; Holliger et al. 1999; Adrian et al. 2000). Anaerobic, sulfate-reducing conditions and relatively high bulk organic carbon levels appear to be needed for enhanced microbial dioxin degradation (Fu et al. 2001). Louchouarn and

Brinkmeyer (2009) reported that anaerobic, sulfate-reducing conditions are present at and below 10 cm in all Houston Ship Channel and Galveston Bay sediments sampled.

Nationally, sediments are considered to be a sink for dioxins (USEPA 2000a). Dioxins entering surface waters partition rapidly to particulates, and preferentially to the organic carbon fractions in suspended solids, and are then transported and/or deposited with bedded sediments. Black carbon (carbon-rich soots and soot-like material) is believed to offer more binding Sites for organic materials but its relative abundance and composition is highly variable; it generally comprises less than 10 percent of the TOC pool in aquatic sediments (Koelmans et al. 2006). The presence of strong sorbing phases such as black carbon and other carbon matrices limit mobility and bioavailability of dioxins and furans and other organic compounds (e.g., PAHs). Koelmans et al. (2006) report that black carbon reduced uptake in organisms by up to two orders of magnitude.

The concentrations of freely dissolved concentrations of contaminants in surface waters and in the sediment biologically active zone, rather than bulk sediment concentrations, determine ecological effects and biological uptake. Contaminants in the near-surface, biologically active and/or physically mixed zone of the sediments, including sediments containing large proportions of pulp mill wastes, may move between solid and aqueous phases and be remobilized from the sediment bed by sediment resuspension and porewater - surface water exchange. Once in the water column, upstream or downstream contaminant transport can occur. Direct biological uptake can also occur from surface and suspended sediments, porewater and surface water. Partitioning between suspended solids and surface and porewater depends on the relative chemical concentrations, organic carbon levels and composition, and the dissolved surface water fraction, as well as reaction kinetics and the partitioning behavior of individual dioxin congeners. These factors are Site- and often sample-specific in the environment. For samples collected from the waste impoundments and the Houston Ship Channel, Louchouarn and Brinkmeyer (2009) modeled porewater concentrations considering both TOC (two-phase model) and amorphous organic carbon and black carbon as separate sorbents (three-phase model). They found that the two-phase model was more conservative in predicting porewater concentrations (i.e., suggesting the two-phase model overestimates porewater concentrations). This effect was greatest at lower dioxin levels. They also note that for samples with very high dioxin levels (e.g., those from the waste impoundments), the sorption capacity of the sediments is exceeded, resulting in very high estimates of dissolved dioxins and furans (greater than 1 pg/L), whereas in most areas, the sediment sorption capacity is estimated to result in dissolved fractions less than 0.1 pg/L.

Tetrachlorinated dioxin and furan congeners may bioaccumulate in aquatic food webs and associated bird and mammal species (ATSDR 1998); more recent literature confirms that other congeners have limited potential to bioaccumulate (USEPA 2008). The principal route of exposure is through the ingestion of contaminated food, as opposed to respiration across gill surfaces for fish or aquatic invertebrates. However, dioxins have been detected in waters, making them potentially available for biological uptake, even at very low concentrations. Certain benthic organisms accumulate dioxins from water at the water–sediment interface and through intake of phytoplankton, zooplankton, and suspended particulate materials that may contain higher concentrations of these chemicals than the surrounding water. Additional discussion of exposure routes and pathways for human and ecological receptors is provided in Section 4.2 and 4.3.

Finally, the bioavailability of dioxins may also be dependent on rates of sediment resuspension and remobilization (Wenning et al. 2004), which will be evaluated as part of the fate and transport evaluation noted below (Section 6.1.5).

4.1.2 Dioxin and Furan Toxicity

Dioxins and furans (polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans) are two groups of structurally similar, tricyclic, almost planar, organic compounds that exhibit similar physical and chemical properties. There are 75 dioxins and 135 furans called *congeners,* which are differentiated by the number and position of chlorine atoms in each congener. Many animal studies have established that there is a distinct difference in the toxic effects among dioxin and furan congeners and that 2,3,7,8-TCDD is the most toxic of the congeners to mammals (USEPA 2000a) and is considered the most toxic to birds and fish as well. Seventeen of the dioxin and furan congeners (seven dioxins, ten furans) exhibit what is termed "dioxin-like" toxicity. These 17 congeners have chlorine atoms present in the 2,3,7, and 8 positions on the ring structure of the molecule and are more toxic than other congeners with fewer chlorine atoms or with chlorine atoms in different positions on the ring structure.

The magnitude of toxicity of each of the 17 dioxin and furan congeners with dioxin-like toxicity are related to the toxicity of 2,3,7,8-TCDD by TEFs. The magnitude of toxicity of each of these 17 dioxin and furan congeners can be related to the toxicity of 2,3,7,8-TCDD using a congener-specific TEF. The concentration of each congener is converted to equivalent concentrations of 2,3,7,8-TCDD by multiplication with its TEF, and all the TEQs for individual congeners (the product of each congener and its TEF) are added to compute the total toxic equivalency of the mixture to 2,3,7,8-TCDD. The resulting total TEQ concentration provides the metric of exposure to "dioxin-like" compounds. Certain PCB congeners exhibit an ability to bind to the same biochemical receptors as the most toxic of the dioxin and furan congeners, and their toxicity is considered to be additive with dioxin and furan toxicity. These "dioxin-like" PCBs also have TEF values for birds, mammals and fish. TEFs for mammals developed by the World Health Organization (Van den Berg et al. 2006) and for fish and birds (Van den Berg et al. 1998) will be used in this risk assessment to estimate the cumulative toxicity of the PCB congeners exhibiting dioxin-like toxicity (Table 4-1).[6]

The mammalian TEFs in Table 4-1 have been recommended for use in human health risk assessments by USEPA (2009). Dioxin and furan congeners without chlorine atoms in the 2,3,7, and 8 positions are assigned a TEF of zero and cannot be evaluated using TEQ methodology because they lack a common mechanism of toxicity.

4.1.3 Site-Related Dioxin and Furan Sources

The impoundments at the Site received pulp mill wastes in the mid-1960s and are presumed to be the major source of COPCs at the Site. Major physical changes that resulted in the exposure of the wastes deposited within the impoundments to surface waters and the distribution of contaminated material into nearby surface sediments. Land subsidence

[6] PCB congeners will be evaluated in initial sediment samples, including those collected from within the impoundments, and will be analyzed in all sediment samples and tissue, if appropriate, according to the decision process described in Section 1.7.2 of the final Sediment SAP (Integral and Anchor QEA 2010) and Section 1.5 of the draft Tissue SAP.

resulting from regional groundwater withdrawal in the 1960s and 1970s contributed to the sinking of the impoundments. As a result of this event, contaminated material was distributed and became distributed and potentially accessible to ecological receptors and to people at the Site. Material from the berm and from within the impoundment was subject to mobilization and redistributed by erosion resulting from tidal and river currents. Dredging activities in the area may have affected the Site. Mobilization of materials by dredging may have released sediment-associated contaminants to the water column that would have settled to the bottom. Determining the spatial extent of sediment contaminants from the impoundments is one issue that will be addressed in the RI/FS.

Human and ecological receptor contact with source material currently exposed within the boundary of the impoundments is also potentially ongoing. A TCRA designed to stabilize the waste material in the impoundments, restrict public access, and minimize the continuing release of wastes to the Site will take place in 2010. The physical/chemical elements of this CSM presume the successful implementation of the TCRA and CSM focuses on the fate and transport of contaminants released to the Site from the impoundments prior to the TCRA. In addition, the CSM will also focus on the permanent cessation of human and ecological receptor contact with the source material."

Given the hydrophobic nature of dioxins and furans and their affinity to be associated with sediment particles, qualitative and quantitative descriptions of hydrodynamics and sediment transport are very important because these physical processes provide the foundation for understanding chemical fate and transport processes in the Site. A Technical Memorandum on Chemical Fate and Transport is being developed that will address the physical modeling and data requirements (Sections 6 and 8). The results of this effort will greatly inform the refinement of the physical CSM for the Site.

At present, the existing sediment dioxin and furan from the area of the Site as well the physical setting of the impoundments within the San Jacinto River can be used to describe a preliminary physical CSM. First, the impoundments were constructed on the inside bend of a natural river oxbow, in an area historically consisting of marshlands (e.g., Figure 2-1). This area was likely a zone of sediment accretion rather than erosion with hydrodynamic energy being directed through the main river channel in the far eastern portion of the Site (i.e., along the outside bend of the oxbow). Second, although there are significant spatial nature and extent data gaps to be filled as part of the RI/FS, analysis of existing data shows a decrease in sediment dioxin concentrations moving away from the waste impoundments (see Figure 4-3). Finally, Louchouarn and Brinkmeyer (2009) reported the results of a fingerprinting analysis of dioxins and furans located in the impoundments, their immediate vicinity, and further afield in the San Jacinto River and the Houston Ship Channel. They graphically presented ratios of TCDD/OCDD versus TCDF/OCDF for each sample to show differences in the characteristics of dioxin mixtures among sediment samples, and thereby to address source inputs to the Houston Ship Channel and vicinity. This particular dioxin compositional analysis shows a decrease in sediment dioxin concentrations from the waste impoundments as well.

4.1.4 Global and Regional Dioxin and Furan Sources, Release Mechanisms, and Transport Pathways

Dioxins have never been purposely manufactured. They are anthropogenically and naturally produced through combustion, bleached paper production, polyvinyl chloride (PVC) production, ink/dye production, metal smelting, or as trace impurities or incidental by-products in chlorophenols, chlorinated herbicides, and commercial Aroclor (PCB) mixtures (ATSDR 1998). Examples of combustion and incineration that may lead to the formation of dioxins include waste (hazardous, medical) incinerators, cement kilns, boilers and industrial furnaces, vehicle emissions, fossil fuel power plants (e.g., coal), and backyard burning (e.g., refuse piles, burn barrels). Dioxins are naturally produced from forest fires, volcanic eruptions, and sedimentary deposits. Currently the largest source of dioxins to the environment is from combustion (USEPA 2006a). Absent a local source (such as the Site waste impoundments), the global source of dioxins and furans in environmental media is generally atmospheric deposition, which has been shown to be a factor in this Region (Section 2.3.5). When released into the air, some dioxins may be transported long distances, even around the globe. In the atmosphere, it has been estimated that 20 to 60 percent of 2,3,7,8-TCDD in the air is in the vapor phase. Sunlight and atmospheric chemicals break down a very small portion of the dioxins, but most will be deposited on land or water (ATSDR 1998) and ultimately be transported downgradient.

Given the long-term generation of dioxins as manufacturing by-products around the world, atmospheric transport, and the general recalcitrance of the molecules, it is expected that some inputs of dioxins to the San Jacinto River system other than from the waste impoundments have occurred. Historically deposited dioxins still present in the river are expected to be predominantly sorbed to sediments.

Figure 4-4 includes a general representation of the regional sources, release mechanisms/transport pathways of dioxins and furans that are additional to the atmospheric inputs. These include industrial effluents, publicly owned treatment works, stormwater from the full range of upland land uses, direct runoff, and surface water and sediment transport into the Site from both upstream and downstream in the San Jacinto River as a function of both river and tidal flows, including infrequent storm surges which may be important in moving large amounts of sediment. It is documented that the nearby Houston Ship Channel is contaminated with dioxins and furans from local industrial and municipal effluents and runoff, as well as atmospheric deposition (University of Houston and Parsons 2006).

4.2 Human Health Site Conceptual Model

For exposure to occur, a complete exposure pathway must exist. A complete pathway requires the following elements (USEPA 1989):

- Source and mechanism for release of constituents
- Transport or retention medium
- Point of potential human contact (exposure point) with the affected medium
- Exposure route at the exposure point

If any one of these elements is missing, the pathway is not considered complete. For example, if human activity patterns relative to the location of an affected exposure medium prevent human contact, then that exposure pathway is not complete. A simple CSM of the release and exposure pathways at this Site is illustrated in Figure 4-4. Figure 4-5 presents a CSM exposure diagram for human receptors based on our current understanding of exposure media, routes of exposure, and potential human receptors for the Site. Further description of the CSM for human exposures is provided below.

4.2.1 Human Health Receptors

Four potential human receptors have been identified for evaluation in the BHHRA to be conducted for the Site as part of the RI/FS process: a recreational fisher, a subsistence fisher, a recreational visitor, and a trespasser. Fishers include children or adults who gather fish from within the Site boundaries either by boat, fishing from along the riverbanks, or wading into the river to fish; fishers are assumed to eat the captured aquatic species. Recreational visitors include people interacting with Site media while swimming, picnicking, or playing along the shoreline, but not consuming fish. Both fishers and recreational visitors are assumed to be residents living in the vicinity of the Site and accessing the Site regularly throughout the year over the duration of their residency. Although recreational visitors may consume fish from the Site that were caught by someone else, exposures by the recreational visitor to contaminants consumed in fish will not be considered directly, but will be considered in the BHHRA in the context of total risks for the fisher receptors.

Signs of trespassers have also been reported along some portions of the Site, particularly under the I-10 Bridge. These individuals may come in contact with Site media in ways similar to the fishers and recreational visitor, but the frequency of their visits and total exposure duration is expected to be much less than the residential-based fishers and recreational visitor. Fishers and recreational visitors are expected to encounter higher exposures than trespassers would encounter. Consequently, if remediation is necessary and the Site is remediated to levels that are safe for fishers and recreational visitors, it will also be safe for trespassers.

4.2.2 Human Health Exposure Pathways

Exposure pathways are defined as the physical ways in which chemicals present in exposure media may come in contact with human receptors. The following potential exposure routes for human receptors are considered in the CSM exposure diagram for human receptors (Figure 4-4):

- Ingestion or dermal contact with chemicals in sediments
- Ingestion of fish and shellfish[7]

[7] Several fish and shellfish potentially consumed by people at the Site are included among the species for which consumption advisories are in place (Section 2.3.7.5).

- Ingestion or dermal contact with chemicals in surface water
- Ingestion or dermal contact with chemicals in soils
- Inhalation of chemicals in air (i.e., gases or particulates)

The frequency and duration of exposures to chemicals in each exposure medium will vary depending on the types of activities associated with each receptor group. Exposure pathways are considered potentially complete and significant if the exposure occurs frequently over an extended duration and the exposure medium represents a significant potential source of Site-related contaminants. Exposure pathways are considered potentially complete, but minor, if the exposure occurs infrequently, over a short duration, or if the exposure medium represents a minor potential source of Site-related contaminants. In Figure 4-5, consumption of fish by recreational visitors is the only incomplete exposure pathway identified. As noted above, this pathway may occur, but will be evaluated separately for the fisher receptor groups.

For the fishers and recreational visitor, potentially complete and significant exposures to Site media are expected to occur primarily via direct contact with sediments or soil (ingestion and dermal) and, for the fishers, also through consumption of aquatic organisms (i.e., fish and shellfish) that are exposed to Site-related contaminants in the sediments. Exposures to these media by trespassers are expected to be minor. Exposures to contaminants in surface water and air are expected to be minor for all groups of potential Site visitors.

4.3 Ecological Site Conceptual Model

The ecological CSM is described in detail in the SLERA (Appendix B) and summarized in this section. The ecological CSM connects the sources and transport pathways described above in Section 4.1 to ecological receptors that may be expected at the Site. The CSM facilitates evaluation of the completeness and significance of exposure to contaminants of concern in each potentially affected environmental medium (Figure 4-6). A more detailed description of specific exposure routes considered to be the most important to each receptor is provided in Figure 4-6. Below is a synopsis of the receptors selected for evaluation in the BERA, followed by a discussion of the details conveyed by Figure 4-6.

4.3.1 Ecological Receptors

Fish and wildlife may be expected to use the habitats present in the vicinity of the Site, including open waters, riparian shorelines, and estuarine and marine wetlands (Section 2.5). From the lists of species that may be present at the Site seasonally or year-round, receptor surrogates were selected to represent the potential exposures to Site-related chemicals. Ecological receptor surrogates are considered to be representative of the trophic and ecological relationships for several other species, as described in Appendix B. In selecting receptor surrogates for the Site, the following criteria were considered:

- Receptor is or could potentially be present at the Site
- Receptor is representative of one or more feeding guilds
- Receptor is known to be either sensitive or potentially highly exposed to COPCs at the Site
- Life history information is available in the literature or is available for a similar species that can be used to inform life history parameters for the receptor

Given the identification of sediments and surface water as primary environmental media of concern for the fate and transport of Site-related chemicals, receptors were chosen that are aquatic-dependent or use aquatic resources to a substantial extent, because these are expected to be the types of organisms with the most potential to be exposed to chemicals associated with the impoundments.

The following surrogate receptors were chosen from each of the major fish and wildlife taxa expected to be present at the Site. Ecological and life history information is provided for each of these receptors in the SLERA accompanying this Work Plan (Appendix B):

- Benthic macroinvertebrate community
- Bivalve molluscs
- Fish
  - Gulf killifish (*Fundulus grandis*): benthic omnivore
  - Black drum (*Pogonias cromis*): benthic omnivore
  - Southern flounder (*Paralichthys lethostigma*): benthic piscivore
- Reptiles

- Alligator snapping turtle (*Macrochelys temminckii)*: omnivore

- Birds
  - Neotropic cormorant (*Phalacrocorax brasilianus*): piscivorous diving waterbird
  - Great blue heron (*Ardea herodias*): wading bird
  - Spotted sandpiper (*Actitis macularius*): invertivorous, sediment-probing bird
  - Killdeer (*Charadrius vociferous*): terrestrial invertivore

- Mammals
  - Raccoon (*Procyon lotor*): omnivore, uses riparian and terrestrial habitats
  - Marsh rice rat (Oryzomys palustris): omnivorous, seasonally variable diet, uses riparian, aquatic, and wetland habitats

4.3.2 Ecological Exposure Pathways

The complete exposure pathways and relevant exposure routes for fish, invertebrates and aquatic-dependent wildlife include direct contact with contaminated water, sediments or soils; ingestion of contaminated water, sediments, soils or prey that have been exposed to contaminated media, and respiration (for aquatic species) see Figure 4-6.

5 STUDY ELEMENTS AND DATA NEEDS

The evaluation of existing data (Section 3) and development of the CSMs are the basis for identifying the additional information that is required to address the objectives of the RI/FS. Each of the objectives will be addressed by a specific Study Element, as described in this section. Although data may inform more than one study element, the organization of the RI/FS into four principal Study Elements provides the framework for effectively communicating how the RI/FS will address each objective, and for planning data collection and analyses, as follows:

- Study Element 1: Nature and Extent Evaluation, to characterize the nature and extent of contamination of sediments and soils and to assess groundwater quality.
- Study Element 2: Exposure Evaluation, to evaluate ecological and human health risks from exposure to COPCs in soil, sediment, water and biota.
- Study Element 3: Physical CSM and Fate and Transport Evaluation, to better describe and characterize the physical processes governing the fate and transport of Site-related COPCs.
- Study Element 4: Engineering Evaluation, to support design of remedial actions, including removal Site-related contaminated sediments and the construction of remedial alternatives.

Data gaps for each Study Element are identified in this section. In Section 5 the specific approach for addressing each of the listed data gaps is described; Section 8 describes the schedule of project deliverables, including SAPs for collection of additional data to address the data gaps identified below.

5.1 Study Element 1: Nature and Extent of Contamination

The nature and extent investigation addresses the COPCs that were defined in the Sediment SAP (Integral and Anchor QEA 2010).[8] COPCs are classified as either primary or secondary. Primary COPCs are those that will be evaluated in the baseline risk assessments. Secondary COPCs are those for which additional information is needed to determine whether they will be evaluated in the baseline risk assessments. Chemicals other than the primary and

[8] The process and data used to identify COPCs is provided in Appendix C.

secondary COPCs will not be evaluated further in this RI/FS (Integral and Anchor QEA 2010).

Information on the nature and extent of primary COPCs in abiotic media resulting from releases of materials from the impoundments is required for the evaluation of remedial alternatives in the FS. The horizontal and vertical distribution and extent of Site-related COPCs in sediment and soils must be described to inform how active remedial approaches and potential for natural recovery processes will achieve remediation goals for the affected media at the Site, and post-remediation recontamination potential. In addition, the possibility that groundwater quality is affected by the Site must be evaluated. Specific data gaps to be addressed by Study Element 1 are described below. Additional information on COPC concentrations in soil sediment and tissue to support the exposure assessment is addressed by Study Element 2.

5.1.1 Soil Data Gaps

There are currently no data to describe the chemistry of soils on the Site, but the Site history and CSM suggest that sediments from within the impoundments may have been transferred to the sand-sorting area of upland portion of the property west of the impoundments. Therefore, appropriate soil data for characterization of the nature and extent of contamination in area on this upland represents a data gap for Study Element 1. This data gap will be addressed by collection of soil data in the upland area using a sampling design that will produce accurate and representative estimates of COPC concentrations in surface soil. Project specific data quality objectives (DQOs) addressing Study Element 1 for soil, and a SAP designed to achieve these DQOs will be developed and presented in the forthcoming soil SAP.

5.1.2 Sediment Data Gaps

Available sediment data from the Site indicate the presence of elevated concentrations of COPCs within and in the vicinity of the waste impoundments, but the data are limited in their spatial location and depth, and many data are qualified because complete QA records are not available (Section 3). Specific limitations of these data include:

- The low spatial density will lead to uncertainty in defining a cleanup boundary if additional sediment chemistry data are not collected.

- The absence of sufficient subsurface COPC measurements, except adjacent to the I–10 Bridge, will lead to a large uncertainty in the depth of contamination and therefore in the sediment depths and quantities to be addressed by remedial alternatives.
- Limitations on the number of samples and the number of analyses of COPCs in upstream background samples limit the accuracy and precision with which background conditions can be characterized, leading to undesirably high uncertainty in comparisons of Site and background conditions.

These data gaps will be addressed by the collection of sediment data using a sampling design that will produce representative estimates of COPC concentrations throughout the area within the preliminary Site perimeter. Measurement of subsurface sediments at multiple locations within this area will provide information necessary to evaluate preliminary remediation goals (PRGs) and remedial alternatives. Project-specific DQOs addressing Study Element 1 for sediment, and a SAP designed to achieve these DQOs were developed and presented in the sediment SAP (Integral and Anchor QEA 2010).

5.1.3 Groundwater Data Gaps

Available groundwater data exists in the form of private and public well information from the region and from wells near the Site, see Section 2.2. Site-specific groundwater chemistry data have not been collected. Additional information on groundwater hydrology and groundwater quality is needed to confirm or refine the groundwater CSM described in Section 2.2. As previously discussed in Section 2.2, the physical properties of both COPCs and the Site hydrogeology indicate it is very unlikely that Site-related impacts to groundwater are present. Nevertheless, local groundwater data will be obtained to determine whether any Site-related impacts are present. To confirm the groundwater CSM described in Section 2, some strategically designed monitoring wells are planned to be completed and monitored during the RI. Three nests of monitoring wells are planned. The nested wells will be located such that lateral and vertical groundwater gradients can be measured. The gradient data can be used to determine local groundwater flow direction and characterize potential groundwater/surface water interaction. The wells will also be used to obtain representative groundwater samples to assess groundwater chemistry and to determine if shallow groundwater quality has been affected by the use of the former impoundments. Section 6.1.5 further describes the plan for groundwater assessment.

5.2 Study Element 2: Exposure Assessment

USEPA guidance requires that an RI include evaluation of baseline risks to human and ecological receptors. "Baseline" in this context refers to the conditions at the Site before remediation takes place. As such, baseline conditions provide a point of reference for evaluation of the no action alternative in the FS, and for post-remedial Site evaluation. Baseline human and ecological risk assessments will be performed for the RI. Study Element 2 addresses the information needs to perform the evaluation of exposures under baseline conditions.

For human receptor groups, primary exposure to Site-related COPCs may include direct contact (ingestion and dermal) with soils and sediments or indirect contact through consumption of aquatic organisms (i.e., fish and shellfish) that are exposed to the sediments. People may also be exposed through direct contact (ingestion and dermal) with surface water or through inhalation of COPCs as particulates or vapors in air, but exposures via these media and routes are expected to be minor or non-existent. Exposure of people to COPCs via groundwater is unlikely (Section 2.2.6); groundwater chemistry collected for Study Element 1 will provide the information required to confirm this assumption. Ecological receptors may be exposed to COPCs through ingestion of sediment, soils, water, and their food; through direct contact with sediments and water; and through respiration in the aquatic environment (Appendix B). Benthic invertebrates and fish may be exposed to groundwater via contact with porewater, but these exposures will be evaluated using biological tissue chemistry, so therefore no direct measures of porewater or groundwater chemistry are needed to assess exposure to ecological receptors. Finally, Study Element 2 addresses those data and processes governing the bioaccumulation of COPCs in fish and invertebrate tissue, which will be needed to calculate risk-based PRGs (Section 7) and may also be used in the risk evaluation.

Additional information on the chemistry of sediment, soil, and biological tissue are needed to perform the exposure evaluation and baseline risk assessments. Information on the chemistry of both abiotic and biological media is needed for evaluation and characterization of processes governing bioaccumulation. Specific data gaps to be addressed by Study Element 2 are detailed below.

5.2.1 Soil Data Gaps

Additional information on the concentrations of COPCs in soil potentially impacted by Site sediments is needed to reliably characterize baseline exposures and risks to people and ecological receptors coming into contact with Site soil. Additional information on the concentrations of COPCs in soils at locations in the terrestrial portions of the Site north of I–10, where human use activities are expected to occur and where terrestrial birds and mammals may be expected is needed to reliably characterize exposures and risks associated with contact with Site soils. Project-specific DQOs addressing Study Element 2 for soil, and a SAP designed to achieve these DQOs, will be developed and presented in the forthcoming soil SAP.

5.2.2 Sediment Data Gaps

Available data for chemicals of interest (COIs) in the sediments within the impoundments indicate the presence of dioxins and furans, several metals and bis-2(ethylhexyl) phthalate at levels that are of potential concern to ecological and human health, and magnesium as potentially of concern to ecological health (Appendix B; Appendix C); these chemicals are the primary COPCs for the baseline risk assessments. In addition, several SVOCs and VOCs could not be ruled out from further evaluation in the baseline risk assessments, and were retained as secondary COPCs for the ERA. PCB congeners, some of which are considered to have additive toxicity with dioxins and furans, also have never been measured in sediments from the impoundments.

For the baseline risk assessments, additional data for sediments within the impoundments are required to characterize sediment exposures and risks in this part of the Site. Available sediment chemistry data are insufficient, however, elsewhere on the Site to characterize specific types of exposures of ecological receptors and people to COPCs with the degree of reliability needed for the baseline risk assessments. Moreover, the focus of existing data on areas near the impoundments and I-10 Bridge prevents accurate assessment of area-weighted exposure estimates; the lack of additional spatial characterization of contamination would therefore lead to possible bias and high uncertainty in exposure estimates and risk estimates for the Site as a whole.

Data gaps to be addressed by Study Element 2 include concentrations of these COPCs in sediments from specific areas of the Site:

- Shallow intertidal sediments in wildlife foraging areas, and beach sediments in human use areas on Site.
- Shallow intertidal sediments from at least one wildlife foraging area upstream of the Site and beach sediments in at least one human use area upstream of the Site to characterize background exposure conditions.

Sediments collected to fill these data gaps will also be useful in the evaluation of bioaccumulation processes. Stations for sampling of tissue will be co-located with these and with stations for characterization of nature and extent of contamination in sediment collected as part of Study Element 1. Project-specific DQOs addressing Study Element 2 for sediment, and a SAP designed to achieve these DQOs, were developed and presented in the sediment SAP (Integral and Anchor QEA 2010).

5.2.3 Water Data Gaps

Available data for water are limited, with only ten samples collected from within the Site in the available data set, and only dioxins and furans analyzed in these samples. Because water chemistry in the brackish estuarine of the Site is highly variable both temporally and spatially, empirical characterization of water chemistry is complex and would require a prohibitively high number of samples. Human exposures via water may be low relative to exposures resulting from ingestion of contaminated sediment and tissue from the Site because people are not expected to ingest substantial quantities of water from the Site. Although fish and invertebrates may be exposed to contaminants in water, evaluation of exposures to these ecological receptors will be through measurement of contaminants in their tissue (for organic COPCs), through concentrations of COPCs in bulk sediment, or through evaluation of the total dose ingested as a result of ingestion of contaminated media. Mammals are unlikely to ingest water at the Site. For birds, the fraction of the ingested dose of any COPC due to ingestion of water, when ingestion of prey and contaminated sediment are considered, is expected to be minor.

Nevertheless, estimates of COPC concentrations in water are needed to address ecological exposures, both for the risk assessment and to understand processes controlling bioaccumulation of COPCs into tissues. Therefore, the concentration of dioxins and furans in water are considered a data gap. The approach to estimating water quality will be presented in the Technical Memorandum on Fate and Transport Modeling as discussed in Section 6.1.5 and the uses of these estimates in the ecological exposure evaluation are addressed in Section 6.4.3.

5.2.4 Tissue Data Gaps

Tissue chemistry data have not been collected within the Site since 2004, and the available data set consists of only 38 samples of edible fish and crab tissue (Section 2.3.6). Baseline risks associated with ingestion of contaminated tissues from the Site cannot be accurately characterized with the available tissue chemistry data. Information on the concentrations of COPCs in fish and shellfish tissue is needed to reliably characterize exposures and risks to people who eat fish caught at the Site, risks to fish and aquatic invertebrates using tissue-based effects levels (for organic COPCs), and to wildlife that consume fish in their diet. Expected data gaps to be addressed by Study Element 2 include concentrations of COPCs in the following types of tissue samples:

- Edible tissue of fishes that have home ranges comparable to part or all of the area of the in-water portion of the Site
- Edible tissue of shellfish likely to spend a significant portion of their lives on the Site
- Whole fish in species that are likely to spend a significant portion of their lives on the Site, can be highly exposed to sediment contaminants and are of size classes that can be eaten by other ecological receptors to characterize exposure to piscivorous fish and wildlife and to the fish themselves
- Tissue of benthic invertebrates to characterize exposure to ecological receptors due to ingestion of prey
- Tissue of bivalve molluscs to address risk to this receptor

Collecting some of these tissue samples (particularly samples of species with small home ranges) at stations where sediments are being collected will facilitate evaluation of tissue-sediment bioaccumulation relationships, if they exist. Other factors that affect chemical bioavailability and uptake (e.g., sediment carbon content) will be considered in the evaluation of bioaccumulation. All relevant tissue, sediment, and water data will be analyzed to develop Site-specific bioaccumulation functions, if possible.

Project-specific DQOs addressing Study Element 2 for biological tissue, and a SAP designed to achieve these DQOs, will be developed and presented in the forthcoming Technical Memorandum on Bioaccumulation, and Tissue SAP.

5.3 Study Element 3: Physical CSM and Fate and Transport Evaluation

Development of the physical CSM and conducting a chemical fate and transport evaluation depend on data and information related to: 1) hydrodynamics; 2) sediment transport; and 3) chemical fate and transport.

Hydrodynamic data needs are:

- Bathymetry and geometry
- River flow rates
- Current velocities
- Water surface (tidal) elevation
- Wind speed and direction
- Salinity

Data and information related to sediment transport are:

- Magnitude and composition of sediment loading in the river
- Bulk bed properties, including grain size distribution and dry density
- Bed type delineation (i.e., areas of cohesive and non-cohesive bed sediment)
- Erosion properties of cohesive bed sediment
- Net sedimentation rates
- Suspended sediment concentrations in the water column

Data and information for chemical fate and transport are:

- Magnitude of chemical loading in the river
- Site-specific parameters for kinetic processes (e.g., partition coefficients, volatilization rates)
- Spatial distributions (horizontal and vertical) of bed chemical concentrations
- Water-column chemical concentrations
- Groundwater quality data at the Site

Most of the hydrodynamic, sediment transport, and chemical fate and transport data discussed above will be used during a computer modeling study that will be conducted for the Site area. The details of data requirements, and related field studies, for the fate and transport modeling study will be included in a forthcoming technical memorandum that will fully describe the modeling study.

5.4 Study Element 4: Engineering Design Evaluation

Engineering data are required to support the development and evaluation of remedial alternatives in the FS as well as to support the design of the selected remedy. The aspects of the engineering evaluation that require additional data include:

- Evaluation of dredging methods and potential water quality impacts associated with dredging
- Evaluation of methods for handling sediment after dredging, potentially including dewatering methods, the sizing of settlement areas and the ultimate consolidation of dredged sediment
- Evaluation of sediment capping methods
- Evaluation of soil strength and consolidation potential in areas where any potential containment systems may be built

To address data gaps related to dredgability and materials handling, geotechnical data will be required from representative sediment samples collected within the river. Index parameters (i.e., moisture content or total solids, grain size, Atterberg limits and specific gravity) will provide information to evaluate the behavior of sediments to be dredged. These data will be used to consider the appropriate size and types of dredge equipment, expected pumping and dredge production rates, sediment dewatering processes, estimated sediment bulking during dredging, and anticipated pre- and post-dredge sediment volumes. Sampling methodology to evaluate dredgability and dredge material handling is described in more detail in the SAP and the FSP (Integral and Anchor QEA 2010).

Geotechnical data gaps will be addressed by obtaining sediment samples and completing geotechnical laboratory tests on those samples, as described in the SAP. A series of borings advanced from the upland and from a barge will be used to collect samples. These borings will be advanced at multiple locations to provide a representative characterization of the subsurface sediment profile.

Strength data will be used to evaluate the bearing capacity and slope stability for the design, construction, and viability of any potential containment systems. Vane shear and consolidated-undrained triaxial (CU triax) test results will be used directly as measures of sediment strength. Standard penetration test (SPT) blow counts and Atterberg limits test results will be correlated to sediment strength using standard-of-practice geotechnical engineering reference sources (e.g., Federal Highway Administration and TXDOT geotechnical manuals).

Settlement data will be used to estimate the magnitude and duration of expected settlement under the footprint of any potential containment systems. The results of this evaluation will be used for planning the crest elevation of the berms and the top elevation of any potential containment systems. Consolidation test results will be used as a direct measure of sediment compressibility. Atterberg limits and moisture content data will be used to correlate expected compressibility parameters using similar standard-of-practice geotechnical engineering references as described above.

Permeability data will be used to evaluate potential fate and transport mechanisms within any potential containment systems. Permeability will be directly measured by the permeability test. Permeability can also be correlated with data reported from the triaxial shear strength test and loosely correlated with grain size data that will be collected.

6 REMEDIAL INVESTIGATION APPROACH

According to USEPA (1998) guidance, the objective of the RI/FS is "to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for [the Site]." Accordingly, the approach to the RI targets and prioritizes the practical information identified in Section 5 that will be required to effectively plan a removal action that will reduce risks from human and ecological exposures to COPCs to acceptable levels. The RI approach considers the urgency of risk management at this Site, as articulated by USEPA in the 2009 UAO, by accelerating decisions, such as the selection of COPCs (Appendix C) in a manner that is thorough, conservative and efficient, to quickly facilitate the Site evaluation and development of remedial action alternatives with relevant and sound information. The approach to the RI is centered on the following functional themes derived from the evaluation of existing data (Section 2) and development of the CSM (Section 4):

- Pulp mill wastes placed in the impoundments in 1965 and 1966 are the source of hazardous chemicals of interest to the RI/FS.
- Site history and the CSM, existing chemistry data for sediments collected from within the impoundments and additional information identifying those chemicals potentially occurring in bleached kraft pulp mill wastes from the 1960s provide a sufficient basis for determination of COPCs for both aquatic and upland portions of the Site at the outset of the RI/FS. Methods, information resources, and data used in the analysis to determine COPCs are documented in Appendix C.
- Dioxins and furans congeners are an indicator chemical group that is diagnostic of chemical releases from the impoundments to the San Jacinto River systems and is likely to dominate Site-specific risks to humans and ecological receptors. Dioxins and furans are an appropriate indicator chemical group for the RI because of their toxicity, their elevated concentrations in impoundment sediments relative to upstream sediments, their distinctive fingerprint associated with the Site (Louchouarn and Brinkmeyer 2009), their environmental persistence and their potential to be transported away from the source (USEPA 1988a). As such, remedial actions taken to address unacceptable risks associated with dioxins and furans are highly likely to effectively remove or eliminate risks due to other COPCs, unless otherwise indicated by the RI results.

- Because COPCs may accumulate in biological tissue, and unacceptable risks to people and ecological receptors are likely to derive largely from ingestion of contaminated food, the ability to accurately predict concentrations of COPCs in tissues using information on abiotic media (sediment and water) is important to defining remediation goals for sediments and related media.
- The Site is located in an area influenced by municipal, commercial, and industrial activities. Chemical contaminants generated outside the Site may be transported into the Site by physical or biological means. Evaluation of risks and remedial actions will consider those influences.
- The environment surrounding the Site is physically dynamic, with sediment and water transported across the Site by the physical action of the river and tidal flows. Characterization of these processes, and their role in the long-term character and degree of contamination at the Site, is critical to determine the appropriate remedial action(s). Basic information on the physical processes connecting the Site to the surrounding areas, and on the levels of chemical contamination in upstream areas, is needed for risk management decisions.

This section provides an overview of the following primary tasks to be performed as part of the RI:

- Site characterization, including characterization of the physical system and nature and extent of contamination in abiotic media and biological tissue
- Characterization of background concentrations of COPCs in abiotic media and biological conditions, and in particular conditions upstream of the Site
- Characterization of ecological risks
- Characterization of human health risks

Each of these sub-sections below describes the approach and types of information to be developed in support of these tasks. Additional details on the conceptual basis, study design sampling and analytical methods, and data evaluation approach for each task will be provided in subsequent deliverables, according to the schedule in Section 8. Additional deliverables anticipated for this RI include the following:

- Bioaccumulation Memorandum and Tissue SAP

- Fate and Transport Modeling Memorandum and Addendum to the Sediment SAP
- Soil SAP
- Groundwater SAP

A Sediment SAP has been drafted in consultation with the USEPA, and it addresses the conceptual basis and methods required to address the sediment data gaps identified in Section 5. Because the draft sediment study design has been completed, a greater level of detail on the study design is provided in this section than for other media. Development of detailed design information for the other components is currently in progress.

6.1 Site Characterization

Physical and chemical measurements will be made both to characterize the Site empirically and also to support evaluations of transport processes, evaluations of bioaccumulation processes, and engineering design. Measurements will be made within preliminary Site perimeter and also within the area. Measurements of sediment and tissue chemistry, and estimated water-column chemical concentrations in these areas will be used to evaluate the primary determinants and effects of exposure to the COPCs.

6.1.1 Sediment

The purpose of investigating chemicals in sediment is to determine the nature and extent of potential contamination to characterize sediment-related exposures of aquatic life, aquatic-dependent wildlife, and people who use the Site and identify any unacceptable risks associated with the contamination and to evaluate potential remedies. To meet these goals, surface sediment from throughout the Site, including upstream and downstream from the waste impoundments, will be collected from three types of areas:

- Submerged sediment throughout the Site, which represents a potential exposure route to benthic macroinvertebrates and some fish and crabs
- Shallow water sediment in locations available to foraging wildlife
- Beaches that may be used by people for fishing or recreation

Subsurface sediment will be collected at selected locations within the Site to evaluate the depth of elevated concentrations of COPCs and to collect geophysical information needed to evaluate remedial alternatives. Subsurface sediment will also be collected at representative beaches that may be used by people, to evaluate exposure that may result from digging activities.

Sediment will be collected from within the waste impoundment area to characterize the chemical profile of material released from this location, as well as to determine the depth and width of contamination remaining in the impoundments. This information will be used to characterize the contribution of COPCs from the waste impoundment to other sediments within the Site. Sediment will be collected from locations within the area that are upstream of the Site itself. Data from these locations will be used to evaluate background conditions and to calculate incremental risk related to exposure of COPCs originating at the waste impoundments.

Details of the sediment sampling design for Site characterization are presented in the sediment SAP. Primary elements of this design are:

- Surface sediment sampling and analysis of primary COPCs at 26 locations in and near the impoundments on a 500-foot (152-m) grid, at 1 location in the channel immediately south of I-10 and toward the western side of the preliminary Site perimeter, and at 4 locations along the eastern perimeter of the original impoundments. Additional sediment from these 31 locations will be archived for later analysis of secondary COPCs, if necessary. Primary and secondary COPCs will be measured at an additional 13 locations on the 500-foot (152-m) grid, at 2 locations near the impoundment, and at 2 locations south of I-10. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Data from locations from within the impoundment area (seven stations), will allow characterization of waste materials and will be used for analysis of potential human exposures within the impoundments (along with existing data) as well as other objectives related to Study Elements 1 to 4. Data from the two locations south of I-10 will provide information on possible prop scour or possible dredging disturbances.
- Surface sediment sampling and analysis of primary COPCs at an additional 15 locations within the Site boundary, on a 1,000-foot (305-m) grid (with some distance adjustments at two stations south of I-10 to place stations within the river rather than on land). These samples will provide data for the nature and extent, exposure, and

fate and transport analyses. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs.

- Collection of cores and analysis of primary COPCs at 12 locations within approximately 1,000 feet (305 m) of the impoundment and at 2 locations south of I-10. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs. These samples will provide data for the nature and extent evaluation and for dredgability assessments. Data from the two locations south of I-10 will provide information on possible prop scour or possible dredging disturbances.
- Collection of surface samples and analysis of primary and secondary COPCs at 11 locations upstream of the Site but downstream of the channelized portion of the San Jacinto River, to allow estimation of local background conditions for the nature and extent, exposure assessments, and fate and transport analysis.
- Collection of intertidal sediment samples at 45 locations in three different human exposure areas on five beaches near the Site to evaluate potential human exposure and whether the beaches represent different exposure conditions for human receptors. Surface and subsurface sediment samples will be collected at all 45 stations at each of the five beaches. Twenty-five of the surface intertidal sediment samples will be analyzed for primary COPCs, with additional sediment archived for possible future analysis of secondary COPCs. Surface sediment samples from the remaining 20 stations will be archived for future analysis of primary and/or secondary COPCs, if necessary.
- In addition, half of the subsurface samples collected at Stations SJSH026 through SJSH035 will initially be analyzed for primary COPCs; the archived subsurface sediment samples from the other half of these stations and all of the subsurface samples from the other two beaches will be archived for possible future analysis of primary and/or secondary COPCs, if necessary.
- Collection of intertidal sediment samples for analysis of primary COPCs at ten locations upstream of the Site, but downstream of the channelized portion of the San Jacinto River, for evaluation of human exposures under upstream background conditions. Surface and subsurface sediment samples will be collected at all 10 stations at this beach. Half of the surface intertidal sediment samples will be analyzed for primary COPCs. The other half of the surface and all of the subsurface samples

will be archived for possible future analysis of primary and/or secondary COPCs, if necessary. Surface samples from these stations will also be used to evaluate ecological exposures.

- Collection of intertidal samples from six locations at two ecological exposure areas on the Site and three locations at one ecological exposure area upstream for characterization of exposure of ecological receptors such as wading birds. These samples will be analyzed for primary COPCs. Additional sediment from these stations will be archived for possible future analyses of secondary COPCs, if necessary.
- Sediment borings at 17 locations and VSTs at 18 locations in the impoundment and in locations around the perimeter berms. Measurements of sediment engineering characteristics (strength and settlement behavior) will be used to support Study Element 4.

Surface sediment samples collected for the nature and extent evaluation will also be used to support the evaluations of exposure of aquatic receptors, chemical fate and transport, and sediment dredgability. Samples collected to support exposure assessments for humans and wildlife and to support remedial alternatives are more specialized in purpose and location and will be collected in nearshore shallow areas.

6.1.2 Surface Water Investigation

Although available surface water data are limited, current concentrations of COPCs in surface water within the Site are comparable to those at upstream locations (Section 2.3.4). In addition to analysis of exposures using sediment and tissue data from the Site, chemical fate and transport modeling and other Site-specific data may be used with appropriate COPC partition coefficients, to predict dissolved COPC concentrations in surface water and porewater. To address exposures, these estimated values would be used to evaluate direct exposure of aquatic receptors to surface waters and incorporated into a bioaccumulation model to estimate exposure of higher trophic level organisms and people (exposures to porewaters are addressed by other means, i.e., tissue concentrations in biota, and the dermal absorption model for people). If large uncertainties in risk assessment results are due to the use of these estimates, then confirmatory sampling of surface water quality conditions may be considered in a future phase of Site investigation. The need for direct assessment of porewater as a means to understand the role of surface water in fate and transport will be determined as a result of more detailed conceptual models that will be performed as a component of phases1 and 2 of the fate and transport analysis (Section 6.1.6).

6.1.3 Biota Investigation

Development of information on the chemistry of biological tissues, as affected by the Site, includes an empirical component in which new tissue chemistry data are collected, and a modeling effort in which the empirical tissue chemistry, as well as related information on the environment in which organisms were exposed, are analyzed to determine whether empirical models to predict tissue chemistry can be developed. Additional empirical information on tissue chemistry is needed for the evaluation of exposure to any receptor that consumes invertebrates or fish, and for the evaluation of risk to invertebrates and fish themselves. Some of the risk analyses anticipated will require tissue collections upstream. Evaluations leading to one or more statistical models to predict tissue chemistry data are needed to support development of risk-based PRGs, and to determine which environmental media plays the greatest roles in exposure and risk for ecological and human receptors. The approach to addressing data gaps for tissue is described generally below. Additional specific information on this subject, and supporting analyses, will be provided in the Technical Memorandum on Bioaccumulation. The DQOs for collection of additional data, as well as the sampling design and all related methods, will be provided in the Tissue SAP.

6.1.4 Tissue Sampling and Analysis

The specific design for tissue sampling is addressed in the Tissue SAP (Integral 2010). The evaluation of existing data and the determination of the overall approach to the RI provide the basis for identification of specific tissue data gaps relating to the exposure assessment (Section 5.2.4) and specification of some design details:

- Tissue samples will be collected to address the data gaps identified in Section 5.2.4, which relate to the need for exposure assessment. To improve the efficiency of the study design, tissue samples will be collected to serve multiple objectives of Study Element 2, to the maximum extent possible.
- Tissue samples, particularly for small home range receptors, will be collected at sub-

set of locations where sediment samples have been collected, to the extent practicable. Tissue samples will not be collected at all sediment sampling locations, but the stations for tissue sampling will be selected to reflect the range of potential sediment exposures of the targeted species, and to provide the appropriate level of statistical certainty for the intended applications in the RI.

- Species to be collected during tissue sampling will be those selected as ecological receptors, or those known to be used by people.
- Tissue samples will be collected to maximize their usefulness in comparisons with existing information (e.g., University of Houston and Parsons 2006), particularly in the human health risk assessment.
- Limited tissue sampling will occur upstream of the Site (with a level of effort no greater than that of the upstream sediment samples to be collected for the exposure assessment) for the purposes of evaluating exposure and risks in upstream background areas.

Tissue samples will be collected to support Study Element 2, exposure evaluation, which relates to the baseline human and ecological risk assessments. To identify analytes for tissue samples collected according to this SAP, analysis of sediment data is required, as follows. Results of sediment chemical analyses from the sediment sampling conducted in May 2010 will be generated prior to the performance of tissue sampling. Once validated chemistry data are available for sediments, results for secondary COPCs will be evaluated for frequency of detection in sediments and for statistical correlation with dioxins and furans in sediment that are representative of the wastes in the impoundments (i.e., one or more of the most common congeners in waste-related sediments). Those secondary COPCs never detected in sediment will not be considered in the risk assessments, and will therefore not be measured in tissue. This approach is conservative because several sediment samples are from directly within the waste impoundments. Secondary COPCs that are detected will be evaluated using risk-based screens, which include consideration of bioaccumulation potential. Those secondary COPCs that are detected at least once and that statistically correlate with representative dioxin and furan congeners will not be evaluated in tissue, because any risk associated with a secondary COPC that correlates with representative dioxins and furans is likely to be addressed by sediment remediation performed to address risk due to dioxins and furans. As noted for sediment COPCs in the Sediment SAP, these decision rules apply unless additional information indicates that a COPC may be present at elevated levels in tissues on Site as a result of exposure to the waste in the impoundments. For example, PCB congeners will be evaluated in tissue, even if they correlate with dioxins and furans, because of the possibility that their toxicity is considered additive with that of dioxins and furans for some endpoints in some species.

Approaches to analyses of the tissue chemistry data are described in Sections 6.3 and 6.4.

6.1.5 Groundwater Investigation

During the RI, groundwater quality at the Site will be investigated, both in the shallow (unconfined) and Upper Chicot Aquifer zones. Information regarding the groundwater investigation scope, methodology and DQOs will be provided in a Groundwater SAP. At this time, it is anticipated that 3 pairs of nested wells (i.e., monitoring the shallow and Upper Chicot Aquifer zones in the same region of the Site) will be installed to obtain groundwater samples and evaluate groundwater quality. In addition, the wells will enable quantification of hydrogeologic characteristics at the Site, such as vertical groundwater flow, if any, localized groundwater flow magnitude and direction, and physiochemical interaction between the San Jacinto River and groundwater.

6.1.6 Chemical Fate and Transport Analysis

The evaluation of chemical fate and transport within the Site will use a combination of data (empirical) and modeling analyses and will be used to address data gaps related to Study Element 3, as well as to provide estimates of water chemistry to address data gaps related to Study Element 2. The primary objectives of the chemical fate and transport analysis are:

1. Develop (CSMs) for sediment transport and chemical fate and transport;
2. Develop and apply quantitative methods (i.e., computer models) that can be used as a management tool to evaluate the effectiveness of various remedial alternatives; and
3. Answer specific questions about chemical fate and transport processes.

Additional information on chemical fate and transport at the Site, and supporting analyses, will be provided in the Technical Memorandum on Fate and Transport Modeling which will

be accompanied by a SAP for sampling to address data gaps specific to Study Element 3. A description of the general approach and sequence of events follows:
Evaluating chemical fate and transport will be accomplished using a phased approach because of the complex interactions between the waste impoundments area and the San Jacinto River. A phased approach will produce the most efficient method for studying chemical fate and transport. Three phases for the fate and transport study are proposed, with the primary tasks of each phase described below. Note that decision points occur near the end of Phases 1 and 2; these decision points will be used to refine and adjust the study design as needed, which will help to maximize efficiency and cost-effectiveness.

6.1.6.1 Phase 1: Data Analysis and Hydrodynamic Modeling

Phase 1 consists of data analysis and hydrodynamic modeling and includes the following tasks:

- Compile and analyze available data related to: 1) hydrology and hydrodynamics; 2) sediment transport and geomorphology; and 3) chemical fate and transport
- Identify data gaps and design field studies to fill those gaps
- Develop preliminary CSMs for: 1) sediment transport; and 2) chemical fate and transport
- Determine primary study questions that need to be answered by modeling and additional analysis to support the RI study
- Conduct field studies to support hydrodynamic modeling
- Analyze hydrodynamic data
- Develop and calibrate hydrodynamic model
- Use hydrodynamic model as a diagnostic tool to:
  - Develop insights about sediment transport and chemical fate and transport within the Site and nearby areas
  - Answer primary study questions related to hydrodynamics
- Refine CSMs for sediment transport and chemical fate and transport
- Refine design of Phase 2 as necessary

6.1.6.2 Phase 2: Sediment Transport Modeling and Analysis

Phase 2 consists of sediment transport modeling and analysis and includes the following tasks:

- Conduct field studies to support sediment transport modeling
- Analyze sediment transport data
- Develop and calibrate sediment transport model
- Conduct sensitivity/uncertainty analysis to evaluate model reliability
- Use sediment transport model as diagnostic tool to
  - Develop insights about sediment transport and chemical fate and transport within the Site and nearby areas
  - Evaluate sediment stability during floods and over multi-year periods
  - Answer primary study questions related to sediment transport
- Refine CSMs for sediment transport and chemical fate and transport
- Determine if Phase 3 is needed
- Refine design of Phase 3 as necessary

6.1.6.3 Phase 3: Chemical Fate and Transport Modeling and Analysis

Phase 3 consists of chemical fate and transport modeling and analysis and includes the following tasks:

- Conduct field studies to support chemical fate and transport modeling
- Analyze chemical fate and transport data
- Develop and calibrate chemical fate and transport model
- Conduct sensitivity/uncertainty analysis to evaluate model reliability
- Use fate and transport model as diagnostic tool to
  - Develop insights about chemical fate and transport within the Site area
  - Evaluate the rate of natural recovery throughout the study
  - Answer primary study questions related to chemical fate and transport
- Refine CSM for chemical fate and transport

Conducting a fate and transport study will produce management tools that can be used to evaluate and compare current and future conditions in the Site. The development of hydrodynamic, sediment transport, and chemical fate and transport models will make it possible to understand how chemicals are transported throughout the Site, to address uncertainties about partitioning of chemicals from sediments to water, and to describe the ultimate fate of these chemicals. Results of the chemical fate and transport model will include predictions of chemical concentrations in the water column and sediment bed. In addition, the models can be used to quantitatively evaluate the effectiveness of potential remedial actions. A detailed description of the modeling study, including field studies, will be provided in a technical memorandum that is currently being prepared.

6.1.6.4 Bioaccumulation and Food Web Analysis

COPCs were identified for further evaluation in the RI if they may be bioaccumulative. Models to predict chemical concentrations in tissue are required for development of PRGs (Section 6.4) and for interpretation of sediment and water chemistry when tissue data do not exist. A Site-specific evaluation of bioaccumulation will be performed to determine whether models to predict COPC concentrations in tissue can be derived. Both statistical and mechanistic models will be evaluated. Such a model, or models, will provide a means to quantify uncertainty associated with predictions of tissue concentrations.

A technical memorandum addressing bioaccumulation modeling will be developed and will be submitted with the Tissue SAP, in June 2010. The memorandum will include a discussion of the literature that provides relevant data or analyses (e.g., Dean et al. 2009), an evaluation of relevant approaches to modeling and will indicate a selected approach and related analytical steps. The technical memorandum will relate directly to the tissue study design.

6.1.7 Source Evaluation

To determine the proportional contribution of COPCs from the waste impoundment to sediments throughout the Site, the chemical fingerprint of sediment in the impoundments will be determined. In addition, five sediment samples and several cores will be collected from the impoundment area to allow the range of conditions within the impoundments to be assessed. These sediment samples will be collected to support the nature and extent evaluation. All primary and secondary COPCs will be measured in these sediment samples.

Sediment samples from throughout the area of the Site, including the source characterization samples from the impoundment, will be evaluated using an unmixing method (non-negative matrix factorization [Lee and Seung 1999]). This method will identify different dioxins and furan patterns that are likely to have produced the dioxin and furan pattern observed in Site sediments. These patterns may be associated with particular sources, and statistical similarity measures will be used to evaluate the relationship(s) between patterns and sources. Sediment samples collected from within the impoundments will be used in this analysis to represent the dioxin and furan pattern of waste material that was deposited in the impoundments. The unmixing analysis, and interpretation of the results in terms of sources, will then be used to produce an estimate of the proportion of source-related material in each Site sample, and in each upstream sample. The pattern of dioxin and furan congeners is expected to allow source material contributions to other sediment samples to be identified and quantified, based on the patterns seen in available data, where tetrachlorinated congeners are relatively elevated in samples from the impoundments (Louchouarn and Brinkmeyer 2009).

6.1.8 Soil Investigation

USEPA has information that indicates an additional impoundment is located south of I-10. This information indicates the additional impoundment contains material similar to that disposed of in the two impoundments located north of I-10. Surface and subsurface soil samples will be taken in and around these impoundments to determine the nature and extent of any actual or threatened releases.

6.2 Background/Reference Area Characterization

Sediment and tissue data collected from locations within the San Jacinto River upstream of the Site will be used to characterize background conditions. In addition, evaluation of the potential for the Site to have affected groundwater will include consideration of background groundwater conditions. Background conditions will be evaluated because programs under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) ordinarily do not remediate to concentrations below background, and risks related to background concentrations of COPCs should be evaluated (USEPA 2002d). The information collected from upstream background locations will provide context for the evaluations of nature and extent, exposure, and risk that will be conducted at the Site, and will be used to support development of PRGs.

As described in USEPA (2002d), contamination at a CERCLA site may be due to releases from the CERCLA site itself, as well as contamination from other sources, including natural and/or anthropogenic sources that are not related to the Site under investigation. According to the OSWER guidance, background is a factor that should be considered in risk assessment and risk management at CERCLA sites. Consistent with this, the broad goal of a background evaluation in the context of an RI/FS is to estimate the levels of chemicals that would exist in environmental media at the Site in the absence of CERCLA-related releases of hazardous chemicals from the Site or releases from other point sources of contamination within the Site.

Background conditions are particularly salient in the case of the San Jacinto River Waste Pits Site. This is because of the urbanized and industrialized regional setting, and the fact that the portion of the San Jacinto River occupied by the Site is influenced by many human activities occurring across the upstream watershed and in the San Jacinto River estuary. Extensive details on the local and regional setting of the Site were discussed in earlier sections of this Work Plan.

To achieve a consistent understanding of the background, the following definitions provided in USEPA (2002d) are adopted for this RI/FS:

- **Background**—"Substances present in the environment that are not influenced by releases from a site and are usually described as naturally occurring or anthropogenic.
    1. ***Naturally occurring*** – substances present in the environment in forms that have not been influenced by human activity; and,
    2. ***Anthropogenic*** – natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA site in question)."
- **Reference Area—**"The area where background samples are collected for comparison

> with samples collected on site. The reference area should have the same physical, chemical, geological, and biological characteristics as the Site being investigated, but has not been affected by activities on the Site…. Background reference areas are normally selected from off-site areas, but are not limited to natural areas undisturbed by human activities."

Various statistical techniques for characterizing background levels of COPCs—ranging from point values (e.g., estimates of background central tendency [CT] and upper background threshold values), to hypothesis testing to compare whether background and Site data are drawn from the same population—may be appropriate for different purposes in the RI/FS process. Background CT estimates can be used, for example, to compare an average exposure point concentration (EPC) for an area of interest within a site—frequently estimated using a 95 percent upper confidence limit (UCL) on the mean exposure area concentration—with the background CT estimate. Background threshold values are often estimated using an upper percentile, an upper prediction limit, or an upper tolerance limit. Background threshold values can be applied in point-by-point comparisons of single concentrations measured within a site with the upper bound of the background concentration range. A background threshold value can also be used to define a "not-to-exceed" value that can be used in establishing PRGs (Singh and Singh 2007). Finally, parametric or non-parametric statistical hypothesis testing can be used as a more robust tool for comparing concentrations from a site, or subareas of a site, with background concentrations. Data for individual samples collected from upstream that are determined to be substantially influenced by the Site using methods outlined in the Section 6.1.5 will not be included in calculations of statistics used to represent background conditions. For this RI/FS, several potential uses of background information have been identified:

- **Risk Characterization—**Background concentrations will be used for comparison purposes in the risk characterization section of the baseline risk assessment. Per USEPA (2002d) direction, USEPA policy recommends an approach for baseline risk assessments that involves addressing site-specific background issues in the risk characterization step of the risk assessment process. Specifically, USEPA (2002d) states that "the COPCs with high background concentrations should be discussed in the risk characterization, and if the data are available, the contribution of background to site concentrations should be distinguished."

- **PRG Development—**Background values provide information that is relevant for risk management and establishing PRGs that will be evaluated in the FS. For example, if a risk-based threshold for a given chemical in sediment was determined to be 10 mg/kg, but the background sediment chemical concentration within the Site estimated from upstream chemistry was 100 mg/kg, the PRG would likely be set to background. Many different statistical techniques for comparing background and Site concentrations may be relevant in the context of PRG development.
- **Cleanup Area Delineation—**As part of the FS, cleanup areas will be defined. One method for this is "hilltopping." This is the process of identifying specific areas that must be remediated within a larger cleanup area to achieve a remediation goal. Hilltopping involves sequentially "removing" values, beginning with the highest concentration and working downward, until the average concentration in the cleanup area reaches the remediation goal. In this process, a "replacement value" must be assumed for those stations that are "removed" in the process. Use of a background value as the replacement value is one potential approach of many that could be employed in the FS process.
- **Remedy Selection—**Hypothesis testing to compare background and site concentrations may be relevant in the context of remedy selection. For example, hypothesis testing to compare background and hypothetical sediment cleanup scenarios could be used in the FS to evaluate whether post-cleanup chemical concentrations would be similar to background or to evaluate the relative risk reduction among cleanup options.
- **Long-term Monitoring Post Remedy—**Background values are one possible metric for evaluating remedy performance based on long-term monitoring results after the remedy is implemented, including but not limited to areas where monitored natural attenuation is the selected remedy.
- **Potential Cap Material Selection—**Background levels such as the 95 percent upper confidence limit (95UCL) of the mean could be among the criteria for selecting capping material.

6.3 Baseline Human Health Risk Assessment

The primary objective of the BHHRA is to evaluate potential adverse health effects attributable to exposure to Site-related contaminants under pre-remediation, or baseline conditions. The results of the risk assessment will facilitate Site management decisions. The results of the BHHRA are likely to overestimate actual risks in order to provide a conservative basis for risk management decisions. The secondary objective of the risk assessment is to assist in the development of PRGs (Section 7.4), or the determination of institutional controls, if necessary, that are protective of people who are potentially exposed to Site-related contamination. To achieve these goals, the risk assessment will be conducted in accordance with national and state guidance, which are cited throughout this section.

Section 4.2 (Human Health Site Conceptual Model) provides important background information for the BHHRA technical approach. The technical approach described in this section consists of the following:

- Evaluation of data usability (Section 6.3.1)
- Screening and selection of COPCs (Section 6.3.2)
- Exposure assessment (Section 6.3.3)
- Toxicity assessment (Section 6.3.4)
- Risk characterization (Section 6.3.5)
- Uncertainty analysis (Section 6.3.6)

An important design component of this BHHRA is a comparison of risks associated with consumption of fish and shellfish caught at the Site versus risks associated with consumption of fish and shellfish caught at other locations regionally throughout the Houston Ship Channel and upstream from the Site. This comparison will provide critical perspective on fish consumption risks associated with regional chemical sources that will not be addressed by remediation at the Site. It is discussed in Section 6.3.5.3.

The 2009 UAO requires that approaches to the exposure and toxicity evaluations be provided to USEPA in two technical memoranda preceding delivery of the USEPA review draft of the BHHRA report: Toxicological and Epidemiological Studies Memorandum and Exposure Assessment Memorandum. Likely to impact the approach and performance of the exposure and toxicity assessments is USEPA's plan to finalize its dioxin toxicity reassessment by December 2010. The possible impact on approaches to the BHHRA, particularly on the toxicity assessment, is addressed in Section 6.3.4.2. Additional specific information on the approaches to be used to characterize regional and upstream human exposures and risks will be addressed in the Exposure Assessment Memorandum. The technical memoranda to support the BHHRA are planned according to the schedule provided in Section 8. The results of all components of the BHHRA will be presented in a comprehensive report, also delivered according to the schedule presented in Section 8.

6.3.1 Data Usability

Historical data were evaluated to determine quality using the information available in the associated reports (Section 3). Evaluation of data for the samples collected during the RI will be conducted according to the SAPs for the individual media (sediment, tissue, and soil). The results of the data usability analysis will be presented in the risk assessment report. In performing calculations to support the risk evaluation, duplicate field sample results will be averaged before use in the risk assessment. All results flagged with R qualifiers (indicating rejection of data) will be excluded from use in the risk assessment. For calculation of media concentrations for COPCs other than dioxins and furans, results flagged with a "U" qualifier will be addressed as appropriate, considering the size of the data set and the number of non-detected results, consistent with USEPA's QA/G-9 guidance (USEPA 2000c). Possible methods include substituting half the detection limit for non-detected results, using the maximum value of the data set, and imputing substitution values using the robust probability plotting method of Helsel (2005).

Two approaches will be used for calculation of 2,3,7,8-TCDD TEQ concentrations: either one-half the sample quantitation limit (SQL) or zero will be assigned to non-detected results for individual congeners. The results of both approaches will be presented in the risk assessment.

6.3.2 Screening and Selection of COPCs

Appendix C presents the sediment COPC screening process. The basis for the screening process was sediment samples collected from within the waste impoundment area because, based on the Site history and CSM; the materials within the original impoundments are considered the source of contamination of sediment, soils, and water at the Site. The screening process also considered the potential for bioaccumulation in tissues. Thus, the chemicals identified as COPCs for sediment will also be considered COPCs for soil and tissue (if they are bioaccumulative). Other media will not be evaluated quantitatively for human exposures (see Section 4.2). Chemical forms will be considered in the risk assessment. For example, mercury will be assumed to be in inorganic forms in soil and sediment and in the form of methylmercury in fish and shellfish tissue.

6.3.3 Exposure Assessment

An exposure assessment estimates the type and magnitude of human exposure to COPCs identified at a Site. Subjects that must be considered during the exposure assessment include the CSM, EPCs, and contaminant intakes. An Exposure Assessment Memorandum, submitted according to the schedule in Section 8, will address each of these subject areas, as discussed below.

6.3.3.1 Conceptual Site Model

The current understanding of human receptors and exposure pathways at the Site is discussed in Section 4.2. The exposure routes that will be evaluated quantitatively include the following:

- Ingestion of and dermal contact with sediment by fishers and recreational visitors
- Ingestion of and dermal contact with soil by fishers and recreational visitors
- Consumption of fish and shellfish by fishers[9]

Exposures to other media are considered minor and will be evaluated qualitatively. The CSM will be re-evaluated if necessary as the understanding of the Site increases during the course of Site investigation activities. If additions or deletions to the list of exposure routes are deemed appropriate, they will be discussed in the Exposure Assessment Memorandum.

[9] Evaluation of human exposures will include the use of tissue chemistry data for one or more aquatic species currently the subject of consumption advisories.

6.3.3.2 Exposure Point Concentrations

To estimate the magnitude of exposure for each of the receptors described above, a representative concentration of each COPC present in a medium, (i.e., EPC) must be calculated. An EPC is a conservative estimate of the chemical concentrations in a medium that a receptor is likely to contact over time (USEPA 1989). Because of the uncertainty associated with estimating a true average concentration, USEPA (1992) recommends calculating the 95UCL of the arithmetic mean concentration in the exposure area. USEPA provides multiple guidance documents for computing 95UCLs (USEPA 2002a, 2006b). Values for the 95UCLs will be computed to represent EPCs as appropriate for the statistical distribution of the data set. The lesser of the 95UCL or the maximum concentration for each COPC in a data set will be used as the EPC for each exposure area.

Baseline data from relevant historical investigations and data from the RI field investigations will be included in EPC calculations. Data will be grouped into appropriate exposure areas, such as the impoundment area or the area adjacent to the upland portion of the property west of the impoundments, considering both the statistical characteristics of the data sets and facilitation of risk management and future land use decision-making.

The Exposure Assessment Memorandum will provide the following information relative to EPCs:

- Determination of exposure areas based on evaluation of statistical characteristics of data sets and risk management considerations
- Sample station locations and sample identification numbers for the data set for each exposure area
- Statistical description of each data set (e.g., summary statistics, distribution testing)
- Determination of appropriate method for calculation of EPC for each data set, including how non-detected results will be handled for each chemical and medium
- EPC concentrations for each exposure area

The Exposure Assessment Memorandum will also address the specific calculations and uses of background and regional exposures in the risk evaluation, and will address developing policy as articulated as a result of the dioxin reassessment being conducted by USEPA.[10]

6.3.3.3 Intake Estimates

To quantify exposure, human intake levels resulting from exposures to COPCs are estimated using exposure algorithms and assumptions. Exposure estimates for ingestion and dermal exposures represent the daily dose of a chemical taken into the body averaged over the appropriate exposure period, expressed as milligrams of chemical per kilogram of body weight per day. The primary source for the exposure algorithms used in this evaluation is USEPA (1989) although other supplemental risk assessment guidance documents also will be used (e.g., USEPA 2004, TAC 350.74-75). The generalized equation for calculating chemical intakes is shown below:

$$I = \frac{EPC \times CR \times EF \times ED \times F \times ABS}{BW \times AT} \qquad \text{(Eq. 6-1)}$$

Where:

- I = intake, the amount of chemical taken in by the receptor (mg/kg body weight-day)
- EPC = exposure point concentration, the chemical concentration contacted over the exposure period at the exposure point (e.g., mg/kg sediment)
- CR = contact rate, the amount of affected medium contacted per unit time or event (e.g., sediment ingestion rate [mg/day])
- EF = exposure frequency, describes how often exposure occurs (days/year)
- ED = exposure duration, describes how long exposure occurs (year)
- F = intake fraction, fraction of medium contacted that is assumed to be from the contaminated source (unitless)
- ABS = absorption factor, an adjustment factor to account for relative absorption of a chemical from the medium of interest compared to absorption from the exposure medium in the toxicity study used to derive the toxicity value (unitless)
- BW = body weight, the average body weight over the exposure period (kg)
- AT = averaging time, period over which exposure is averaged (days)

The variables shown in the exposure algorithm above are called exposure factors and vary depending on the receptor population being evaluated. Each receptor population (i.e., fishers

[10] http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209690

and recreational visitor) will be characterized by a number of parameters unique to the receptor population and the exposure pathway. Several regulatory agency and literature sources will be considered when deriving parameter values, including but not necessarily limited to the following:

- Risk Assessment Guidance for Superfund (RAGS) Volume I Part A (USEPA 1989)
- RAGS Volume I Part B – Development of Risk-Based Preliminary Remediation Goals (USEPA 1991)
- RAGS Volume I Part C – Risk Evaluation of Remedial Alternatives (USEPA 1991)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (USEPA 1991)
- Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA 1993)
- Soil Screening Guidance: User's Guide (USEPA 1996)
- Exposure Factors Handbook (USEPA 1997a)
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002c)
- RAGS Volume I Part E – Supplement Guidance for Dermal Risk Assessment (USEPA 2004)
- Child-Specific Exposure Factors Handbook (USEPA 2008)
- Texas Administrative Code sections containing exposure equations and parameters (TAC 350.74-75)

Exposure factors specific to each receptor and chemical intake equations specific to each exposure pathway will be provided in the Exposure Assessment Memorandum. For example, consumption rates for fish and shellfish will be described in the memorandum. A wide range of values for fish ingestion rates are available from various sources including, but not necessarily limited to, USEPA (2000b, 2010), TCEQ (2003) and TDSHS (2005a), which will require a detailed analysis of applicability and validity for the BHHRA.

The exposure factors will include values for a reasonable maximum exposure (RME) scenario and a CT scenario for each receptor, as defined by USEPA (1989), and will be calculated using data generated by the Site investigations. The RME scenario is a combination of high-end and average exposure values that is used to represent the highest exposure that reasonably could occur. The CT scenario is based on average estimates of exposure. The RME scenario provides a conservative estimate of exposure that is plausible but is still well above the average exposure level, while the CT exposure provides a conservative estimate of typical exposure for most individuals within a population and is useful for comparing with the RME. Exposure estimation under both conditions will provide additional risk characterization information for the risk management and remediation decision making process.

6.3.4 Toxicity Assessment

The purpose of a toxicity assessment is to evaluate the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. Standard procedures for assessing and quantifying the toxicity of the COPCs will be applied in the risk assessment (USEPA 1989). These procedures will include identifying toxicity values for cancer and non-cancer health effects and summarizing other relevant toxicity information. The Toxicological and Epidemiological Studies Memorandum, submitted according to the schedule in Section 8, will summarize the relevant literature on the COPCs and the toxicity criteria used in the BHHRA.

6.3.4.1 Toxicity Criteria

Potential risks of cancer and non-cancer health effects from exposure to Site-related chemicals will be evaluated using quantitative toxicity values. As recommended by USEPA (2003b) and consistent with TCEQ (2009) guidance, the toxicity values that will be used in these analyses are, in order of preference, values available in USEPA's Integrated Risk Information System (IRIS),[11] then USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) from the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center.[12] If neither IRIS toxicity values nor PPRTVs are available, then toxicity values may be obtained from other documented sources, such as the Agency for Toxic Substances and Disease Registry's

[11] Available at http://www.epa.gov/ncea/iris/.

[12] Values available through USEPA's preliminary remediation goal (PRG) database, which is available at http://www.epa.gov/reg3hwmd/risk/human/index.htm.

(ATSDR) Minimal Risk Levels.[13] Cancer and non-cancer toxicity values that will be used in the risk assessment will be provided in the Toxicological and Epidemiological Studies Memorandum.

To assess carcinogenic health effects, cancer slope factors (CSFs) are used to assess oral and dermal exposures. CSFs are upper-bound estimates of the carcinogenic potency of chemicals that are used to estimate the incremental risk of developing cancer, corresponding to a lifetime of exposure at the levels estimated in the exposure assessment. In standard risk assessment procedures, estimates of carcinogenic potency reflect the conservative assumption that no threshold exists for carcinogenic effects (i.e., that any exposure to a carcinogenic chemical will contribute an incremental amount to an individual's overall risk of developing cancer). The CSF values recommended by USEPA are conservative upper-bound estimates of potential risk. As a result, the "true" cancer risk is unlikely to exceed the estimated risk calculated using the CSF, and may be as low as zero (USEPA 1986).

Carcinogen toxicity values that will be used in the risk assessment likely will vary in the type of data used to calculate the CSFs and the strength of the evidence supporting the values. Chemicals for which adequate human data are available are categorized as "known human carcinogens," while other values with varying levels of supporting data may be classified as "likely human carcinogens," "suggestive of human carcinogenicity," "not likely to be carcinogenic," or, perhaps, data may be inadequate to make a determination of carcinogenicity.

The potential for non-cancer health effects from long duration exposures via ingestion or dermal contact is evaluated by comparing the estimated daily intake with a chronic oral reference dose (RfD). USEPA (1989) defines the RfD as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. These toxicity values represent average daily exposure levels at which no adverse effects are expected to occur during chronic exposures. RfDs reflect the underlying assumption that systemic toxicity occurs as a

[13] Available at http://www.atsdr.cdc.gov/mrls/index.html.

result of processes that have a threshold (i.e., that a safe level of exposure exists and that toxic effects will not be observed until this level has been exceeded).

The RfDs for many of the non-carcinogenic chemicals are based on laboratory animal studies. Variations in the strength of the underlying data are reflected in the uncertainty factors used to calculate the toxicity values and the confidence ratings assigned to the toxicity values. Uncertainty factors are used in the derivation of RfDs to account for limitations in the underlying data and are intended to ensure that the toxicity value calculated based on the data will be unlikely to result in adverse health effects in exposed human populations. The magnitude of the total uncertainty factor used for a particular chemical varies depending on the nature and the quality of the available toxicity data.

Assessment of dermal exposures relies on modified oral toxicity values. Route-to-route extrapolation assumes that after a chemical is absorbed into the bloodstream, the health effects are similar regardless of whether the route of exposure is oral or dermal. This assumption may be employed for some chemicals with pharmacokinetic characteristics that are similar regardless of route of administration; however, for many chemicals, factors such as absorption, metabolism, distribution, and elimination vary by exposure route, leading to substantial differences in toxicity. The reliability of route-to-route extrapolation is another source of uncertainty that must be considered when interpreting the risk assessment results.

6.3.4.2 Toxicity of Dioxins and Furans

Relevant general information on the assessment of toxicity of dioxins and furans, use of TEFs and calculation, uses and meaning of the TEQ for both human and ecological receptors is provided in the discussion of the CSM in Sections 4.2 and 4.3. For the evaluation of toxicity to people, the CSF for 2,3,7,8-TCDD is applied to the TEQ to estimate potential risks associated with exposure to dioxins and furans. This process is consistent with TAC 350.76(e), except that the Van den Berg et al. (2006) TEFs represent an update to the TEFs recommended in the Texas Administrative Code.

A slope factor developed by USEPA (1985) Office of Health and Environmental Assessment will be used for calculating cancer risks. A draft USEPA (2000a) reassessment of dioxin and furan toxicity and slope factors has been issued, but is still undergoing external peer review.

USEPA plans to release a completed toxicity reassessment by the end of 2010, subject to further consideration of the science.[14] If the dioxin reassessment is finalized in time its conclusions will be incorporated into the Toxicological and Epidemiological Studies Memorandum or the BHHRA. In any case, the findings of the draft reassessment (USEPA 2000a) and more recent evaluations of dioxin and furan toxicity will be addressed by the Toxicological and Epidemiological Studies Memorandum. The use of alternative slope factors for 2,3,7,8-TCDD will be examined in the uncertainty analysis (Section 6.4.5.3). The oral CSF will be evaluated for use as a surrogate for the dermal toxicity factor. Because HEAST does not provide an RfD for 2,3,7,8-TCDD, ATSDR's chronic method reporting limit (MRL) will be used for assessing non-cancer health effects.

6.3.5 Risk Characterization

Quantitative estimates of exposure and toxicity are combined to yield numerical estimates of potential health risks. Baseline risks at the Site will be evaluated in accordance with USEPA (1989) guidance. Risk characterization also involves interpreting and qualifying the derived risk estimates. As appropriate, and consistent with guidance, risks will be summed across chemicals and pathways. The methods that will be used are described below.

6.3.5.1 Calculation of Cancer Risks

The cancer risk estimates derived using standard risk assessment methods are characterized as the incremental probability that an individual will develop cancer during his or her lifetime due to exposure to Site-related chemicals resulting from the specific exposure scenarios evaluated in the BHHRA. The term incremental reflects the fact that the calculated risk associated with Site-related exposure is in addition to the background risk of cancer experienced by all individuals in the course of daily life. Cancer risk estimates are expressed as unitless values reflecting the probability that an individual will develop cancer at some point over a lifetime as a result of exposure at the levels assumed during the BHHRA. Excess (incremental) lifetime cancer risks for the ingestion and dermal exposure pathways will be calculated using the following equation:

[14] Discussed at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=209690.

$$Cancer\ Risk = Intake\left(\frac{mg}{kg \cdot day}\right) \times CSF\left(\frac{mg}{kg \cdot day}\right)^{-1} \qquad \text{(Eq. 6-2)}$$

Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium will be combined to estimate the total cancer risk associated with each exposure pathway (USEPA 1989; TCEQ 2008). Where exposures may occur through multiple exposure pathways, total cancer risks for each exposure pathway will be summed to determine the total cancer risk for the potentially exposed population.

6.3.5.2 Calculation of Non-Cancer Risks

In contrast with carcinogenic effects, potential non-cancer health effects are not expressed as a probability. Instead, non-carcinogenic health risks are characterized as a simple ratio between Site intake and the non-cancer RfD (Section 6.3.5.2). If receptors are exposed to levels less than or equal to the RfD, no adverse health effects are expected. Exposures above the RfD do not necessarily mean that adverse human health effects will occur, but rather that further evaluation is required.

To evaluate non-cancer risks, the ratio of the average daily intake to the RfD is calculated as the hazard quotient (HQ). If the value of the HQ is less than or equal to one, no adverse health effects are expected. If the value of the HQ is greater than one, then further risk evaluation is needed. The HQ will be calculated using the following equation:

$$HQ = \frac{I}{RfD} \qquad \text{(Eq. 6-3)}$$

Where:

HQ	=	hazard quotient (dimensionless)
I	=	average daily intake (mg/kg-day)
RfD	=	reference dose for the COPC (mg/kg-day)

As an initial evaluation of aggregate risks, the HQs will be summed for all chemicals in each exposure pathway to determine a non-cancer hazard index. Such an approach reflects a conservative method for estimating non-cancer health risks because the non-cancer health risks associated with chemicals that affect different target organs are unlikely to be additive. If any hazard indices are found to exceed one, chemicals will be grouped into categories affecting the same target organ, and hazard indices will be recalculated by target organ.

6.3.5.3 Background Risk Comparisons

Natural and anthropogenic background sources of COPCs, other than those of the Site, may affect chemical concentration in samples collected from the Site. If these levels exceed risk-based concentrations, it is necessary to differentiate between the Site-related and background-related sources in order to properly characterize risks related to sources originating from the Site and, if appropriate, develop Site-specific cleanup levels. Concentrations of COPCs in samples collected from the Site will be compared to COPC concentrations in samples collected from background areas using applicable statistical approaches outlined in guidance (e.g., USEPA 2002b).

Capture and ingestion of fish/shellfish consumption is expected to be a significant exposure pathway at the Site. Risks will be calculated for the fish/shellfish consumption pathway based on Site and both upstream and regional background tissue concentrations, and the incremental difference between the Site and background risks will be computed. The background tissue EPCs will be calculated using data representative of the Houston Ship Channel as well as locations upstream of the Site. The comparison between Site risks and background risks will be a critical component in understanding Site risks relative to regional risks and it will be important in evaluating remedial alternatives.

The comparison of Site risks to background risks will not necessarily be conducted for soil or sediment exposure pathways for two reasons. First, the risks associated with these pathways are not expected to be as significant as the risks associated with the fish/shellfish consumption pathway. Second, the organisms consumed by people at the Site, and fish in particular, are mobile and can therefore bring chemical contamination to the Site. If this is occurring, it is important to evaluate both risk and remedial options in the context of quantitative information on the influence of background on Site risks, so that the actual reductions in exposure that may be attributable to remedial actions can be specifically addressed.

6.3.6 Uncertainty Analysis

The exposure assessment involves the use of a number of variables, assumptions, and factors that vary over time and across populations. The accuracy of the assumed values is therefore associated with varying degrees of uncertainty. For example, actual values of exposure factors such as the daily rate of soil or sediment ingestion are expected to vary from individual to individual. In addition, review of the technical literature shows that measuring soil or sediment ingestions rates is technically challenging and poses the potential for measurement errors and uncertainties. Because of these uncertainties, the assumptions in the risk assessment are selected so as to conservatively present potential risks. Furthermore, USEPA (1995, 2000d) guidance requires that risk assessments include an uncertainty analysis that allows risk managers to understand the reliability and representativeness of the risk estimates.

Comparison of the CT and RME risk results is one method of evaluating variability of risks at the Site. In addition, a semi-quantitative evaluation of the uncertainties associated with the results will be presented along with an estimate of the influence of each uncertainty (e.g., whether the uncertainty would tend to lead to an over- or underestimation of potential risks can be addressed qualitatively). The BHHRA report will summarize and discuss each source of uncertainty in both the exposure assessment and the toxicity assessment, identifying which sources are considered most important. A sensitivity analysis will be conducted to evaluate the impact of using alternative values for the key parameters contributing most to uncertainty.

The combined results of the comparison of CT and RME results, the semi-quantitative evaluation, and the sensitivity analysis will provide risk managers important perspective on the risk results and the degree of uncertainty associated with the results, allowing risk managers to evaluate whether a more quantitative analysis of uncertainty and variability is required. For some sites, probabilistic analysis can provide a more complete and transparent characterization of the risks and uncertainties than is possible using the point estimate approach described in this Work Plan (USEPA 2001). In probabilistic risk assessment, probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate distribution, from which an upper-bound value representing an exposure at approximately the 95th percentile of the distribution is selected to represent the RME. The uncertainty analysis will provide a discussion of whether a probabilistic risk assessment approach would add critical information to the Site decision making process.

6.4 Baseline Ecological Risk Assessment

The BERA will produce Site-specific estimates of ecological risks, refining the conservative preliminary estimates presented in the SLERA (Appendix B). The SLERA provides general information on the ecology, habitats, and ecological receptors that are or may be present at the Site; provides a generalized ecological CSM; discusses the basis for the screening process for selection of COPCs using the available data for the Site and screening level assessment endpoints; and describes the rationale for selection of receptor surrogates. The SLERA includes an attachment that provides a listing of ecological receptors potentially at the Site, and an attachment that provides a general description of the toxicity of dioxins and furans to benthic macroinvertebrates, reptiles, fish, birds, and mammals. Appendix C documents the considerations, data, and analyses performed to select COPCs for the RI. This section describes the approach to conducting the BERA, including assessment endpoints, measures of exposure and effects, risk questions, and application of the data generated by studies described in Section 5.1 to characterize risk to ecological receptors. It provides an overview of how results of the BERA will be presented. The receptor surrogates to be addressed directly by the BERA are discussed briefly in Section 4.3.1, and are listed in Table 6-1.

6.4.1 Assessment Endpoints and Risk Questions

An assessment endpoint is "an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes" (USEPA 2003b). Assessment endpoints indirectly communicate the effect of interest, for each receptor group, that will be addressed by the risk assessment. Clear assessment endpoints guide the direction of the risk assessment and tools to be used in the analysis and communicates the meaning of the results to be generated by the BERA.

The SLERA (Appendix B) uses screening level assessment endpoints to provide the basis for conservative judgments to select COPCs; assessment endpoints for the BERA are selected for accuracy rather than conservatism. The final USEPA guidance for conducting ERAs (USEPA 1999) emphasizes population level concerns: "Superfund's goal is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota." Therefore, for the BERA, the attributes of populations, rather than individuals, are the subject of the assessment endpoints. Although this approach is consistent with guidance and generally with societal goals, (i.e., other than for endangered species, environmental management is not usually concerned with the health of individual organisms) application of population-level assessment endpoints can present practical challenges in CERCLA programs. For example, evaluation of trends in wildlife populations using field studies can take many years. Moreover, the vast majority of literature that is available for interpretation of exposures to toxic chemicals reports on individual endpoints, such as survival, growth, and reproduction of the individuals tested by the study. Those that do report on populations often do so for Site-specific field investigations, which often do not have broad applications because exposures are to a mixture of multiple chemicals unique to the Site studied, and which limits the applicability of the result elsewhere.

To overcome these practical challenges for the Site BERA, assessment endpoints reflecting the concern of risk management with the preservation of populations were selected, recognizing that analyses and technical resources (e.g., toxicity literature) to be used may address effects on individuals. This approach is consistent with USEPA guidance on the development of assessment endpoints (USEPA 2003a).

Table 6-2 lists each receptor category, the assessment endpoints to be addressed for that receptor, and the risk questions for each. This table illustrates the conceptual links between the assessment endpoints and the lines of evidence to be used to address each. It also captures the scope of overall approaches to be used in the BERA. The remainder of this section reviews the assumptions captured by the ecological CSM, and describes the measurements, methods, and tools to be used to address each risk question for each receptor category, addressing each of the following:

- Measures of exposure
- Measures of effects
- Characterization of risk and uncertainty

6.4.2 Ecological Conceptual Site Model

Ecological receptors and exposure pathways at the Site are discussed in Section 4.3 of this Work Plan; Section 4 of the SLERA (Appendix B) provides the assumptions that guide the approach to exposure assessment and defines the terminology employed in the text below. In this context, the receptors and exposure routes that will be evaluated quantitatively include the following:

- The benthic macroinvertebrate community exposed through direct contact with the benthic environment (sediment, porewater, and surface water)
- Bivalve molluscs exposed through direct contact with the benthic environment (sediment, porewater, and surface water)
- Fish (in all feeding guilds) exposed through ingestion of sediment and food, and respiration of water
- Reptiles exposed through ingestion of sediment or soils, water and food
- Birds (in all feeding guilds) exposed through ingestion of sediment or soils, water (for seabirds only), and food
- Mammals exposed through ingestion of sediment or soils and food

Other routes of exposure, such as inhalation of contaminated particulate matter by terrestrial mammals, are considered minor or incomplete, and will not be addressed by the measures of exposure to be used in the BERA (Figure 4-6).

6.4.3 Measures of Exposure

According to the CSM, aquatic receptors may be exposed to COPCs through respiration (e.g., via transport of dissolved chemicals across the gills), ingestion, and direct contact. In many cases, the specific route of exposure cannot be discerned from the available literature, or it is not important to the interpretation of the potential for toxicity, because exposures in the literature are expressed simply as concentrations in water, sediment, or organism tissue (see Appendix B, Section 4). Therefore, measures of exposure selected for the BERA to address aquatic receptors include concentrations of COPCs in the following general categories:

- Surface water (mg/L)
- Bulk sediment (mg/kg dry weight [dw])
- Tissue of whole fish, or benthic macroinvertebrates (mg/kg wet weight [ww]; mg/kg

lipid weight)
- Bird egg tissue (mg/kg ww; mg/kg lipid weight), estimated from concentrations in diet of birds

Exposures to birds, mammals, and reptiles occurring through respiration (inhalation) or dermal absorption will not be evaluated in the BERA, as discussed in Section 6.4.2 and in the SLERA. Therefore, measures of exposure selected for the BERA to address terrestrial receptors will be the concentrations of COPCs in the following general categories:

- Surface water (mg/L)
- Sediment (mg/kg dw)
- Soils (mg/kg dw)
- Tissue of whole fish (mg/kg dw)
- Tissue of benthic organisms (mg/kg dw)
- Bird egg tissue (mg/kg ww; mg/kg lipid weight), estimated from concentrations in diet of birds

For all applications, concentrations of COPCs in water will be estimated using a model (Section 6.1.5); the approach will be described in a technical memorandum on Fate and Transport Modeling (Section 8). Concentrations of dioxins and furans, as TEQs, in bird eggs are needed to evaluate risk to birds, and will be estimated from concentrations in the birds' food; ingestion rates of birds, as mg/kg-d, will also be estimated and compared to TRVs. Methods to perform this estimation are under review, and will be addressed in the Bioaccumulation Technical Memorandum (Section 8).

For the exposure assessment in the BERA, a model to combine several of these metrics for evaluation of exposure to fish is described in Section 6.4.3.1. Dose calculations from combinations of one or more of these metrics for evaluation of exposure to terrestrial receptors exposed via ingestion of multiple media are described in Section 6.4.3.2. Statistics of these categories of information that will be used to represent EPCs for each of these media are described generally for aquatic and terrestrial receptors in Section 6.4.3.3.

6.4.3.1 Aquatic Life

To evaluate exposure of fish through ingestion, concentrations of COPCs in each ingested medium (food and sediment) will be compared to the toxicity reference value (TRVs) expressed as dietary concentrations (mg/kg diet). Where multiple prey types are likely to be ingested by a fish (e.g., small fish and invertebrates), the concentration in the overall diet will be calculated using the following algorithm:

$$[COPC]_{diet} = \sum f1[COPC]_1 + f2[COPC]_2 + fn[COPC]_n \qquad \text{(Eq. 6-4)}$$

Where:

$[COPC]_{diet}$ = concentration of the COPC in the overall diet (µg/kg ww)

$[COPC]_{1\ldots n}$ = concentration of the COPC in the prey items 1 through n (µg/kg ww)

$f_{1\ldots n}$ = fraction of prey items 1 through n in the overall diet (unitless), based on mass, the sum of which does not exceed 1

This method is primarily applicable to the assessment of exposure of fish to metals and PAHs, because reliable TRVs expressed as critical tissue residues (CTRs) for metals and PAHs are often not available for these compounds. USEPA (2007) cautions against the use of CTRs for assessment of risk to aquatic organisms from exposure to metals (with the exception of organometals such as tributyltin and methylmercury), unless a toxicologically valid residue-response relationship supports the use of the CTR threshold. PAHs are metabolized by fish and may not appear in tissues, even though ingested PAHs could have adverse effects (e.g., Meador et al. 2006).

6.4.3.2 Aquatic-dependent Wildlife

To estimate exposures to birds, mammals, and reptiles, the cumulative daily dose to each wildlife receptor through ingestion of food and water, including incidental soil or sediment ingestion, will be calculated using the general:

$$Daily\ Dose = \frac{\left(\left(FIR \times C_{food} \times ABS_{food}\right) + \left(WIR \times C_{water}\right) + \left(SIR \times C_{sed} \times ABS_{sed}\right)\right) \times AUF}{BW} \qquad \text{(Eq. 6-5)}$$

Where:

Daily Dose = COPCs ingested per day via food, water, and sediment (mg/kg bw/day)

FIR =	food ingestion rate (kg food dw/day)
C_{food} =	concentration in prey items (mg/kg food dw)
ABS_{food} =	bioavailable fraction absorbed from ingested prey items (unitless)
WIR =	water ingestion rate (L water/day)
C_{water} =	concentration in water (mg/L water)
SIR =	sediment ingestion rate (kg sediment dw/day)
C_{sed} =	concentration in sediment (mg/kg dw)
ABS_{sed} =	bioavailable fraction absorbed from ingested sediment (unitless)
AUF =	area use factor (unitless); fraction of time that a receptor spends at the Site relative to the entire home range
BW =	species body weight (kg)

Exposure factors (e.g., ingestion rates, dietary preferences, and body weights) will be evaluated for each species based on data compiled in the USEPA's *Wildlife Exposure Factors Handbook* (USEPA 1993) and other ERAs conducted within USEPA Region 6. Food ingestion rates may be estimated using the equations presented in Nagy (2001) or derived from literature reports on the life histories of the receptor surrogate species.

6.4.3.3 Exposure Statistics

USEPA guidance (USEPA 1997a) directs ecological risk assessors to consider an exposure profile for each receptor, which can include an expression of the range, the probability distribution, or other representations of exposures. For each of the measures of exposure listed for both terrestrial and aquatic receptors, statistics to express exposure may include the following:

- The concentration in an individual sample. This metric is often used for sediments and water to characterize exposure to benthic and fish.
- An expression of the CT of the data for a COPC in any given media. The best expression of the CT will be dictated by the distribution of the data. Candidates include the median, arithmetic mean, or geometric mean. Other statistics may be used to express the CT in the BERA, as appropriate.
- An expression of the RME concentration. For the mean, the selection of the metric for the RME will depend on the characteristics of the data. Candidates include the

maximum concentration, the 95 UCL of the mean, and the 90th percentile.

The choice of the measure of exposure depends on the risk question, the risk analysis method, and the degree of uncertainty in the overall risk calculation that is considered acceptable. In the final iterations of the risk analysis, probabilistic risk calculations based on characterization of the statistical distribution of one or more exposure parameters may be performed as a way of clearly assessing the effect of uncertainties on the risk estimate. In this case, exposure will be expressed as a probability distribution that is appropriate to the level of detail and amount of information available for the exposure media or exposure metric of interest. Decisions about where to apply this method will be made during the analysis phase of the BERA.

6.4.4 Measures of Effects

Consistent with the discussion of assessment endpoints in Section 6.4.1, measures of effects on ecological receptors will address changes in survival, growth, or reproduction resulting from exposure to one or more COPCs. This approach is a function of the toxicity information likely available in the literature to interpret ecological exposure estimates for the Site. For invertebrates, the literature and some benchmarks address higher levels of organization such as populations and communities. Effects measures that address individual or higher level effects relating to population level impacts will be used if they are available; all effects measures will be related to the assessment endpoints, which address population-level environmental values. These approaches are reflected in the risk questions in Table 6-2.

For the San Jacinto River Waste Pits BERA, Site-specific exposure estimate will be interpreted on the basis of TRVs available in the literature.

6.4.4.1 Toxicity Reference Values

When using published toxicity literature to establish measures of effect, the specific effects measure depends on the experimental design that was used. For example, a toxicity study may provide a threshold dose above which a reduction in the hatchability of bird eggs occurs. In this case, the effect is reproduction, and the measure is the lowest observed adverse effect level (LOAEL) at or above which effects are observed. TRVs, which encompass both LOAEL and no observed adverse effects level (NOAEL) values, can be expressed in several ways. TRVs to be used in the BERA include the following:

- Bulk sediment concentration (mg/kg) for the benthic macroinvertebrate community
- Concentrations in water (mg/L) for fish
- CTR values for dioxin and furan compounds (or other organics) expressed as concentration in whole clams (mg/kg ww or lipid)
- CTR values for dioxin and furan (or other organics) compounds expressed as concentrations in whole fish (mg/kg ww or lipid)
- Concentrations of metals in media ingested by fish (mg/kg)
- Daily ingested dose (mg/kg-d) for reptiles and mammals for all COPCs, and for birds for COPCs other than dioxins and furans

The types of individual effects measures to be derived from the literature will be limited to those clearly relating to population-level effects. These are generally the survival, growth, and reproduction of tested individuals. Studies documenting an effect of a toxicant on an endpoint that is clearly related by the authors of the study to survival, growth, or reproduction will be used (e.g., a developmental endpoint that is clearly related to the reduced survival of young). Studies addressing unrelated endpoints (e.g., cellular or biochemical alterations or gene expression) will not be used to establish TRVs for the BERA, because these effects cannot be related to population-level assessment endpoints.

6.4.4.2 Species Sensitivity Distributions

Generally, individual TRVs from the literature will be compared directly to Site-specific exposure estimates. In these cases, the TRV will be selected to provide the best representation of the receptor on the basis of taxonomy and the lifestage tested relative to those of the Site-specific receptor. Use of literature-based TRVs to interpret Site-specific exposures results in uncertainty when the literature reports a TRV developed for one species (e.g., duck) and it is used to interpret exposures of another species (e.g., great blue heron). To address uncertainty in the applicability of a TRV to the risk assessment, one or more cumulative distribution functions derived from multiple effects-level metrics with a species, or species sensitivity distributions (SSDs) derived from may be developed using multiple literature values for multiple species may be developed.

Within-species cumulative distribution functions and SSDs allow consideration of the variation in dose-response of a given chemical across several life stages or species that have been tested; SSDs and have been successfully developed for dioxins and furans (e.g., Steevens et al. 2005) and other chemicals. SSDs allow the risk assessor to evaluate an individual receptor within the context of its broader ecological or taxonomic group. For instance, if an exposure estimate to a particular COPC exceeds a TRV generated for mammals, then further analysis of the distribution of available TRVs, using an SSD, can be used to determine whether only one mammal species, or multiple mammal species or genera are likely to be affected at the exposure level. The meaning of a single-species cumulative distribution functions or of an SSD depends on the data quality and the types of inputs; each will be interpreted according to the specific information included in the distribution. For suitable toxicity data, additional toxicity metrics (e.g., EC_{10}) for individual taxa may also be derived from data for one or more studies, and used to improve the precision of risk statements. All studies providing TRVs will be evaluated for quality and applicability of these methods prior to development of single species cumulative distribution functions or SSDs, and related decisions will be clearly documented. The use of these types of distribution functions or development of additional metrics (such as the EC_{10}) will allow for more detailed characterization of the risks and uncertainties of effects of COPCs at the Site.

A method to extrapolate TRVs between species on the basis of the difference in body weights between the two species, called allometric scaling, has been used at some Sites. However, the technical basis for extrapolation of TRVs between species based on body size is not as well established for ecological receptors as it is for extrapolations relating to human health risk assessment (i.e., rat to human extrapolations), where it is most widely applied. Because of uncertainty in the use of allometric models to scale TRVs between species, particularly for birds, extrapolations on the basis of body size will not be used to estimate or derive measures of effects when species-specific TRVs are not available.

6.4.5 Characterization of Risk and Uncertainty

Each risk question represents an independent line of evidence that will be applied to address risks to each receptor. All lines of evidence involve the evaluation of the exceedance of an (TRV) by exposures that may occur on the Site (Table 6-2). Factors contributing to the interpretation of the exceedance include the adverse effect(s) represented by the TRV exceeded or the SSD, and the type of threshold exceeded (i.e., LOAEL, NOAEL, EC_{10}). A statement of risk that incorporates all lines of evidence for a given receptor, and addresses qualitative and/or quantitative analysis of uncertainty, will be provided in the risk characterization.

COPC and receptor-specific HQs will be calculated for the initial evaluation of risk. If the HQ indicates that the COPC is present at levels at the Site that could result in an unacceptable risk, the exposure and effects levels may be compared probabilistically, which will provide a more accurate indication of the probability of adverse effects in the risk statement. Coupled with information about the severity of the potential effect, the risk statement for each receptor will address the type, severity, and likelihood of adverse effects on assessment endpoints. When risks of exposure to a chemical are considered unacceptable, the incremental risk relative to background will be evaluated.

6.4.5.1 Calculation of Hazard Quotients

To determine the HQ for ecological receptors, the ratio of the exposure estimate to the TRV will be calculated. If the value of the HQ is less than or equal to one, no adverse health effects are expected. If the HQ is greater than one, additional analyses or studies are warranted. The HQ will be calculated using the following equation:

$$HQ = \frac{E}{TRV} \tag{Eq. 6-6}$$

Where:

HQ	=	Hazard quotient
E	=	Estimated exposure
TRV	=	Toxicity reference value for the COPC

Units used for of exposure estimates and for the TRV may vary among lines of evidence, but must be the same for the numerator and denominator in the HQ equation. Individual HQs will be calculated for each chemical, with the exception of dioxins-like compounds, for which exposure and toxicity to fish birds and mammals can be integrated for multiple chemical congeners (Section 4). Additivity of toxicity and risk for an individual receptor exposed to multiple chemicals (other than dioxins and furans) will not be considered or reported.

6.4.5.2 Probabilistic Risk and Uncertainty

Estimating parameter values used in exposure and risk models is associated with uncertainty. The BERA will include an uncertainty analysis to provide risk managers information on the reliability and representativeness of risk estimates. Some uncertainties will be addressed by making assumptions or representing exposures to be somewhat conservative, (i.e., to overestimate risk). However, the BERA should also represent a realistic portrayal of baseline risk at the Site, so the BERA will not employ extreme conservatism or use methods that compound conservative uncertainties.

For the qualitative uncertainty evaluation, each type of uncertainty will be listed, and each qualified as to whether it results in an over- or underestimation of risks. The BERA will discuss which sources of uncertainty have the greatest effect on uncertainty.

When calculated HQ is greater than one, a probabilistic risk analysis may be used to provide a more complete and transparent characterization of risks and uncertainties than is possible using a HQ alone. As for the BHHRA, a probabilistic risk assessment requires that probability distributions are assigned for one or more exposure parameters to yield an output probability distribution for the exposure estimate distribution. From this distribution, a value representing a certain likelihood of exposure can be derived, allowing a more specific expression of risk as the likelihood of adverse effects. TRVs can also be represented as a probability distribution in a probabilistic analysis.

6.4.5.3 Addressing Population Level Assessment Endpoints

Population level assessment endpoints have been selected for the BERA, consistent with USEPA guidance (USEPA 2003a), but TRVs from the available literature providing measures of effects are likely to generally represent individual-level endpoints (i.e., those related to survival, growth and reproduction of individual organisms), particularly for birds and mammals (e.g., Appendix B, Attachment B2). Population-level effects can be addressed using simple population models (such as Leslie matrices) where the toxicity literature provides the means to address one or more relevant life stages. Derivation of cumulative distribution functions for toxicity data for a single species will also allow the risk statement to provide conclusions about the population level effect (e.g., the EPC is at a level that causes no effect in 90 percent of individuals in this age class).

In some cases, population level assessment endpoints may need to be addressed qualitatively, on the basis of the toxicity data that provides the TRV. For example, if there is only one acceptable toxicity study reporting a 20 percent reduction in hatchability of bird eggs at the LOAEL, the HQ will be interpreted in the context of the uncertainties of the exposure assessment and the source of the TRV to state whether a potential effect on the population exist. Population level effects will be considered negligible for receptors and COPCs if HQs are less than one.

6.4.5.4 Characterization of Background Risks

Background ecological risks will be characterized in two ways: based on upstream background conditions, and based on regional conditions. Both types of evaluations will be performed to provide perspective on risks associated with the Site, and will allow an assessment of the incremental risks due to the Site. An incremental increase in risk relative to background can potentially be directly affected by controls at the Site. In cases where incremental risk is evaluated, it will be evaluated for both upstream background and regional background for comparison to Site risks.

Background risks will not be calculated for all receptors and COPCs, but will be performed when the BERA concludes that there is an unacceptable risk to an assessment endpoint from a COPC. Therefore, evaluation of risks in upstream background areas will be conducted using the same general lines of evidence as for evaluation of Site specific risks, but may use existing data sets, or may require estimation of parameters that will be measured on Site. Where estimated EPCs are used, related uncertainties will be documented and addressed in the comparison.

Data collection to address ecological exposures in upstream areas has been specified in the Sediment SAP (Integral and Anchor QEA 2010). Whether upstream background samples of other media are collected will be determined by the DQOs presented in the Soil SAP and Tissue SAP.

7 FEASIBILITY STUDY APPROACH

7.1 Feasibility Study Process

The FS will be submitted in accordance with the schedule contained in the scope of work (SOW). The FS process will be sequenced as follows and explained in more detail later in this section. It includes the following eight steps:

1. Develop Remedial Action Objectives (RAOs)
2. Identify Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered Criteria (TBC)
3. Define Preliminary Remediation Goals
4. Identify and Characterize Management Areas
5. Identify and Screen Remedial Technologies
6. Develop and Screen Alternatives
7. Complete a Comparative Evaluation of Alternatives
8. Select Preferred Alternative

7.2 RAOs

RAOs will be developed for the Site based on the conclusions of the RI and the developed CSM. The RAOs will be aimed at protecting human health and the environment and will focus on the media and contaminant(s) of concern, exposure route(s) and receptor(s). The RAOs coupled with the ARARs and risk assessment will be used to develop the PRGs.

7.3 Preliminary Identification of ARARs

A complete list of potential ARARs will be developed for the Site. The ARARs will fall into one of three classifications:

- **Location-specific**. These requirements provide restrictions on activities based on the Site characteristics or its environment.
- **Chemical-specific**. These requirements are health- or risk-based concentration limits or ranges for specific hazardous substance, pollutants, or contaminants in various environmental media.
- **Action-specific**. These requirements are controls or restrictions on particular types of activities such as hazardous waste management or wastewater treatment.

In addition, TBCs, which include non-promulgated criteria, guidance, and proposed standards issued by federal or state governments, will also be listed for the Site. Although TBC compliance is not mandatory, TBCs may provide guidance on how to carry out certain actions or requirements.

7.4 PRG Development

PRGs for sediment and soils provide the foundation for the development and evaluation of remedial alternatives. Several different factors play a role in the development and refinement of Site-specific PRGs:

- Risk-based concentrations
- Background conditions
- Risk reduction prioritization
- Mass removal goals
- ARARs

The data and information generated by the RI will be used to derive PRGs for sediment and soil.

PRGs are primarily risk-based and are intended to achieve targeted levels of risk reduction at the relevant scale of exposure for a given risk scenario or receptor. Risk based PRGs are then evaluated with respect to constraints imposed by ARARs, background chemical concentrations and the technical and economic feasibility of particular remedial approaches. The process of developing PRGs therefore starts with development of Site-specific protective concentration levels (PCLs) in abiotic media that meet the target risk levels over a relevant scale of exposure for a given receptor and/or risk scenario. For humans and each different ecological receptor, separate PCLs will be generated for different exposure routes, such as direct contact, sediment ingestion, and ingestion of food items that have bioaccumulated COPCs for the Site. PCLs are not developed for full exposure scenarios that involve exposure to multiple media (e.g., ingestion of fish and sediment). Methods for conducting the baseline risk assessments that produce these PCL values are described in Sections 5.3 and 5.4. Exceedance of a cumulative target risk level within a given exposure unit potentially can be addressed through remediation to several different PCLs for different chemicals (e.g., equivalent risk reduction may be achieved through remediation of a large area of moderately elevated concentrations of one chemical or a small area of highly elevated concentrations of a different chemical). If applicable, several different sets of equally effective PCLs (in terms of risk reduction) will be carried forward for further consideration in the FS. The initial risk-based PRG for each chemical will be the minimum PCL for any receptor (human or ecological) and any exposure route.

For sediment, the initial PRGs will be compared to the concentration of each COPC in background sediment. Depending on the type of PRG and how it will be applied, comparisons to different types of background statistics would be warranted.

Remediation of Site sediment to concentrations below background is not required by USEPA under CERCLA (USEPA 2002b). If the initial PRG for any COPC is statistically significantly lower than the mean background concentration, the PRG will be set equal to the relevant background value.

During the detailed evaluation of remedial alternatives (described in Section 7.9), feasibility constraints may be identified that make achievement of a PRG unlikely or impossible. Affected PRGs may then be revised to accommodate these constraints. Two ways in which the PRGs may be revised include:

- Revision or reprioritization of target risk levels. For example, a revised PRG may be selected that meets the target risk level for human exposures, but exceeds the risk level for an ecological receptor.
- Development of a PRG based on mass removal goals rather than on concentration. This approach would lead to direct determination of a remedial area boundary based on optimization of mass removal relative to feasibility constraints.

If a PRG is revised in either of these (or other) ways, the overall response action may include restoration activities in addition to remedial activities. Instead of revising the PRGs, feasibility constraints may also be addressed by applying a combination of remedial approaches, such as institutional controls on Site access in addition to the use of removal or isolation technologies. All of these decisions are within the purview of risk managers and will be made in close consultation with USEPA.

7.5 Identify and Characterize Management Areas

The Site will be subdivided into management units based on the following factors:

- Physical: water depth, sediment dynamics, structures, slopes, sediment gradation, and other related factors will be identified.
- Chemical: chemical concentrations will be compared against PRGs to identify differing levels of contamination.
- Biological: resources within the Site will be identified. Certain habitats or biological resources may warrant substantially different remediation approaches, levels of effort, time frames, or other tradeoffs. For example, in some areas, the environmental costs may outweigh the environmental benefits of cleanup.

The unique management areas will be the basis for developing alternatives. In addition, the areas and volumes will be used to help screen technologies and evaluate alternatives.

7.6 Identify and Screen Remedial Technologies

The material in the waste pits are source materials that contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to ground water, to surface water, to air or acts as a source for direct exposure. (USEPA 1991 "*A Guide to Principal Threat and Low Level Threat Wastes"*). The purpose of identification and screening of remedial technologies is to evaluate cleanup alternatives for all principal threat and low level threat wastes associated with the site source materials and nature and extent areas.

USEPA expects to:

- Use treatment to address the principal threats posed by a site, wherever practicable.
- Use engineering controls, such as containment, for wastes that pose a relatively low long-term threat or where treatment is impracticable.
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment residuals and untreated waste.

- Use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances.

USEPA guidance for contaminated sediment remediation identifies "three major approaches: Monitored Natural Recovery (MNR), in-situ capping, and sediment removal by dredging or excavation" for addressing sediment sites (USEPA 2005b). The technologies considered in the FS will therefore focus on the following (or a combination of the following):

- MNR or Enhanced MNR
- In situ capping
- Dredging or excavation combined with the following auxiliary technologies:
  - Transport
  - Materials handling (i.e., treatment)
  - Disposal

Each technology is discussed in more detail below. In addition, during the FS, each technology will be evaluated on USEPA's Threshold Criteria (overall protection of human health and the environment; compliance with ARARs), Primary Balancing Criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost) and Modifying Criteria (state/support agency acceptance; community acceptance).

7.6.1 Monitored Natural Recovery

Per USEPA's sediment remediation guidance (USEPA 2005b), MNR is a remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. MNR may rely on a wide range of naturally occurring processes to reduce risk to human and/or ecological receptors. These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. Depending on the contaminants and the environment, this risk reduction may occur in a number of different ways including destruction (degradation or transformation) of chemicals, reduced mobility or toxicity, burial, and/or dispersion. A variation of MNR is enhanced MNR where one of the driving mechanisms (usually burial) is accelerated. A common method of enhanced MNR is the placement of a thin layer of sediment over the affected area.

The FS will assess the degree and spatial extent to which MNR or enhanced MNR can be expected to be a suitable remedy that meets the RAOs. This will involve modeling of chemical fate and transport within and around the Site to determine how quickly and to what level chemical concentrations in surface sediments where organisms and people are exposed can be expected to decrease over time. The chemical fate and transport model being developed will be used to assist with MNR modeling. To the extent that this model is not available, other models or estimation methods may be employed. This modeling will be supported by a thorough evaluation of empirical information to determine whether MNR has occurred historically. This information may include (but is not limited to) evaluations of sediment samples taken over time and evaluations of concentration profiles in cores. The timeframes for acceptable MNR or enhanced MNR will be set to be consistent with appropriate guidance.

7.6.2 Capping Technologies

In situ caps isolate contaminated sediments from the environment by use of natural or constructed products. Caps consist of two main components:

1. Chemical isolation component. This portion of the cap reduces the flux of the solids and dissolved contaminants to the overlying water column to acceptable levels. The chemical isolation component is typically made of naturally occurring sands or gravels. Additives such as organoclay or other products have been used to help sequester more mobile dissolved contaminants.
2. Erosion protection component. This portion of the cap protects the chemical isolation component from erosion. The gradation and thickness of this layer is such to resist potential erosive forces such as currents, waves, or propeller wash. The erosion protection layer can be constructed from either be naturally occurring gravels or boulders or manufactured products (e.g., cement).

The FS will review various capping technologies and present the advantages and disadvantages of each. The FS will also focus on likely placement techniques for each component. Screening will be used to focus the probable cap technologies and account for the following factors:

- Sediment strength and stability
- Site constraints for a cap, such as slopes, water depths, and currents
- Presence of structures, such as piers, piling, and outfalls, as well as debris
- Navigational constraints
- Short-term water quality impacts during construction
- Erosive environment
- Equipment availability
- Capping production rates

7.6.3 Dredging or Excavation Technologies

Dredging or excavation technologies are used to dislodge and remove contaminated sediments from the waterbody for subsequent transport and disposal. Dredging or excavation can be accomplished either using mechanical or hydraulic means. The FS will review the dredging or excavation technologies commonly used for contaminated sediment remediation projects in the Gulf Coast. Screening will be used to focus the probable dredge or excavation technologies and account for the following factors:

- Sediment strength and grain size
- Depth of contamination
- Dredge or excavate area constraints such as slopes, water depths, and currents
- Presence of structures, such as piers, piling, and outfalls, as well as debris
- Navigational constraints
- Short-term water quality impacts during construction
- Equipment availability
- Support equipment and materials required
- Dredging or excavation production rates
- Volume of excess water produced that will need to be managed

Dredging or excavation will be coupled with a number of auxiliary water quality controls and technologies including transportation, treatment, and disposal. Each of those controls and technologies is discussed in more detail below.

7.6.3.1 Water Quality Controls

As dredging or excavation occurs, measures will likely be required to minimize and/or contain potential water quality impacts. These potential controls include implementation of dredging or excavation best management practices (BMPs), permeable and/or low permeability silt curtains, a barge de-water treatment system(s), use of geotubes, and/or use of settling basins. In addition, a system for sheen and spill prevention and response will be developed. BMPs could include adjustments to dredging or excavation techniques and/or equipment, operation times, and production rates.

Screening of water quality controls will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Geotechnical properties of the sediment subgrade
- Dredging or excavation technology used
- Dewatering technology and location (i.e., upland or on barge)
- Predicted water quality impacts associated with dredging or excavation
- Volume of excess water produced that will need to be managed
- River hydrodynamic conditions
- Water depth
- Navigational constraints
- Potential secondary impacts associated with implementation of proposed controls (e.g., adverse water quality impacts cause by installation or operation of the control)
- Timeline for implementing the control(s)
- Permitting requirements

7.6.3.2 Dredge or Excavation Material Handling (Transportation and Treatment) Technologies

7.6.3.2.1 Transportation Technologies

After the material is dredged or excavated, the sediment will need to be handled and transported before disposal. Transport technologies include pipelines, barges, trucks, rail cars, and combinations of the above. An offloading facility may also be required in some combinations where the sediment has to be transferred from the water to upland. Screening of transportation technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Volume of excess water produced
- Sediment bulking potential
- Removal technology used
- Site access
- Production rates
- Equipment availability
- Short-term water quality impacts during construction
- Navigational constraints
- Size and configuration of offloading facility
- Disposal Site location
- Disposal Site material requirements
- Disposal Site permits

Transportation technologies that are sustainable will be promoted to the extent practicable, including those that:

- Minimization of air toxics emissions and greenhouse gas production
- Conserve natural resources and energy

7.6.3.2.2 Treatment Technologies

The FS will identify treatment technologies for screening and inclusion in the alternatives. Per USEPA guidance (USEPA 2005a) "in-situ treatment, is currently under development and may become a viable alternative in the future." Based on previous contaminated sediment experience nationally and in Region 6 sediment treatment considered in the FS will be limited to ex-situ technologies:

1. Physical treatment: physical force is applied to the sediment or water. Examples of physical treatment include separation technologies such as geotubes, hydrocyclones, gravity separation, or filtration.
2. Chemical treatment: chemical reactions bring about changes to the sediment or water. Chemical treatment is commonly used in conjunction with physical treatment to enhance contaminant removal or immobilization.

On the basis of past experience, treatment technologies are anticipated to consist only of dewatering or stabilization/solidification. Dewatering removes excess water from the dredged or excavated material. Stabilization/solidification immobilizes contaminants in sediment using chemical treatment. The reaction occurs with the use of such materials as cement, fly ash, or other similar materials. A beneficial side effect of the reaction is the improved handling characteristics of the sediment. Screening of treatment technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Volume of excess water produced
- Removal and transport technology used
- Production rates
- Equipment availability
- Short-term water quality impacts during construction
- Disposal Site location
- Disposal Site material requirements

7.6.4 Disposal Technologies

Disposal could be on-site within a potential containment system or off-Site. Off-site disposal of the sediment dredged or excavated from the Site would need to be at a permitted Subtitle C or Subtitle D landfill, as appropriate.

Disposal at an on-site potential confined disposal facility will require dewatering and capping. Sediment would be placed within the potential confined disposal facility either mechanically or hydraulically. The sediment would be allowed to settle. The carriage water would be discharged back to the San Jacinto River after the appropriate settling time necessary to meet discharge requirements. Geotubes may be a remedial option used to facilitate settling.

Disposal at an off-site landfill will likely require dewatering, offloading, and transport by truck or rail to the landfill. The offloading could occur at the Site, but may also be at an off-site location.

Screening of on-site and off-site disposal technologies will focus on the following factors:

- Sediment physical properties, such as grain size, water content, and plasticity
- Removal, dewatering, and transport technology used
- Availability of potential waste handling areas
- Equipment availability
- Disposal site characteristics (area and depth)
- Disposal site location
- Disposal site material requirements
- Risk associated with off-site transport

7.7 Develop and Screen Alternatives

Using the list of qualified technologies determined during the screening process, a limited number of cleanup action alternatives will be developed. Each alternative will consist of an assembly of specific actions that would be taken in each management area to address the RAOs and PRGs. As required by the National Contingency Plan (NCP), a No Action alternative will be used as a baseline for evaluating and comparing the other alternatives. The alternatives will be based on the qualified technologies, the cleanup action characteristics, the RAOs and PRGs, and current and future Site use requirements.

The FS will provide the following information on each alternative:

- Summary of the rationale behind each alternative developed
- Scope of each alternative including the technologies used and anticipated sequencing:
  - Remedial areas, volumes, depths and thicknesses, and other pertinent quantity estimates
  - Equipment and labor to be used
  - Materials to be used
  - Upland facility requirements (staging areas, transfer facility, disposal Site, haul routes, etc.)
  - Likely durations and schedule

The FS will screen each of the alternatives against the following criteria:

- **Effectiveness**. Each alternative will be evaluated regarding how well the alternative meets the RAOs and ARARs; how well the alternative reduces mobility, volume, and toxicity; and how well the alternative provides safety to workers, the public, and the environment during construction.
- **Implementability**. Each alternative will be evaluated with regard to its technical feasibility, the availability of necessary resources, and the administrative feasibility.
- **Cost**. The cost of each alternative will be estimated by determining the present worth of each alternative considering direct and indirect capital costs, as well as long-term maintenance and monitoring costs. Per USEPA guidance the FS-level cost estimate will be within the range of -30 to +50 percent (USEPA 1993). MIMC and IP may also factor in other financial considerations including, but not, limited to risk management, insurance costs, and costs associated with marine and upland operation interruptions.

7.8 Comparative Evaluation of Alternatives

The FS will assess each alternative against the nine CERCLA criteria described below. The results will be compared to identify the key tradeoffs between them. This comparative evaluation will provide sufficient information to adequately evaluate the alternatives. The No Action alternative will be used as a baseline for the comparisons.

As part of the comparative analysis, each alternative will be ranked for how well it meets each of the criteria. Rankings will be as follows:

- High: alternative meets all of the requirements of a criterion
- Medium: alternative meets most, but not all of the requirements of a criterion
- Low: alternative meets only some of the requirements of a criterion

The nine criteria are:

- Threshold Criteria
  - Overall protection of human health and the environment
  - Compliance with ARARs
- Primary Criteria

  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, and volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost
- Secondary Criteria
  - State and tribal acceptance
  - Public acceptance

An overview of the threshold and primary criteria is presented below. The Secondary Criteria will be assessed following receipt of USEPA comments on the Draft FS.

7.8.1 Threshold Criteria

Each alternative must meet the two threshold criteria discussed in this section.

7.8.1.1 Overall Protection of Human Health and the Environment

This criterion provides an overriding evaluation on the adequacy of the alternative to protect human health and the environment and what measures are required to make the alternative adequate. This criterion will draw on other criteria assessments, especially long-term effectiveness and permanence and short-term effectiveness.

7.8.1.2 Compliance with ARARs

The criterion will determine if the alternative is compliant with all federal and state ARARs. If an ARAR cannot be met, the basis for justifying a waiver will be presented.

7.8.2 Primary Criteria

7.8.2.1 Long-term Effectiveness and Permanence

The highest ranking will be assigned to those alternatives that demonstrate permanence of the actions proposed, stability of the sediments, and lowest potential for recontamination. Determination of long-term effectiveness of combined alternatives will be conducted including, as relevant, sediment and water quality thresholds related to sediment chemical concentrations, sediment resuspension, advective/diffusive flux from sediments to surface water, and fate and transport to biota. Various methods for evaluation of capping effectiveness could include comparison of porewater concentrations to surface water criteria and establishment of Site-specific risk-based sediment criteria consistent with the risk assessment. Although these methods will be considered, these example methods do not necessarily have to be used in the FS.

7.8.2.2 Reduction of Toxicity, Mobility, and Volume through Treatment

The highest ranking will be assigned to those alternatives that provide the greatest reduction (collectively) in the mobility, volume, and toxicity of contaminants. The impacts of the alternatives are focused on the effectiveness at reducing the ability of contaminants to move by advection or diffusion, the volume of contaminated sediment in the Site after construction, and the toxicity of contaminants in the sediment to ecological or human receptors.

7.8.2.3 Short-term Effectiveness

The highest ranking will be assigned to those alternatives that present the least risk to workers and have the fewest water quality, quality of life, biota, and operational impacts.

In keeping with the goal of enhancing the environmental benefits of the selected remedial alternative, technologies and practices that are sustainable and consistent with project needs will be promoted, including:

- Employment of renewable energy and energy conservation and efficiency approaches
- Use of cleaner fuels, diesel emissions controls and retrofits, and emission reduction strategies
- Use of water conservation and efficiency approaches
- Incorporation of sustainable site design
- Use of reused or recycled industrial materials within regulatory requirements
- Requirements for recycling or reuse of materials generated at or removed from the Site
- Use of environmentally preferable purchasing

- Support of greenhouse gas emission reduction technologies
- Use of Environmental Management System (EMS) practices, such as reducing the use of paper by moving to fully electronic transmittal of project documents and implementation of waste reduction and recycling programs at all work Sites.

7.8.2.4 Implementability

Implementability will focus on technical and administrative feasibility and availability of materials and equipment. The highest ranking for technical feasibility will be those alternatives that demonstrate technologies with proven project performance, are available from multiple contractors/vendors, and offer the highest reliability and the least risk of delay. The highest ranking for administrative feasibility will be those alternatives that require the least amount of agency coordination and action. Alternatives that minimize permit and access agreements will be more administratively feasible. The highest ranking for availability will be those alternatives using technologies that are available from multiple contractors or vendors, where the need for specialized equipment and/or labor is minimized, and the risk from delay is minimized.

7.8.2.5 Cost

The highest ranking for cost will be alternatives with the lowest present worth cost. Costs will include direct and indirect capital costs, as well as long-term maintenance and monitoring costs. Per USEPA guidance the FS-level cost estimate will be within the range of -30 to +50 percent (USEPA 1993).

7.9 Select Preferred Alternative

The FS will provide a detailed description of the preferred alternative that was determined to best fulfill the evaluation criteria.

8 RI/FS SCHEDULE

The schedule for deliverables related to the RI/FS for this Site is provided by Figures 8-1a and 8-1b. This schedule was developed in consultation with the USEPA, and reflects the following considerations:

- The schedule conforms in content and prioritization to the schedule provided by the 2009 UAO except that the numbers of days between submittals is presented in standard business days, not calendar days, and that a Preliminary Chemical of Concern (PCOC) Memorandum will not be submitted, because COPCs have already been identified.
- Time shown in the schedules for review by the USEPA is estimated. Deviations from the schedule, due to the review process are possible and will impact the deliverable dates of subsequent documents. Deviations from this schedule will be discussed with USEPA as required.
- The 2009 UAO requires submittal of monthly progress reports, which are not shown in Figures 8-1a and 8-1b.
- Each monthly progress report, starting July 15, 2010, will include the most current version of the project schedule.

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TABLES

Table 2-4
Data Sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
ENSR and EHA (1995)	Edible	Blue crab	1	10/1/1993	10/1/1993	1	Dioxins and furans
ENSR and EHA (1995)	Fillet	Blue catfish	1	10/1/1993	10/1/1993	1	Dioxins and furans
ENSR and EHA (1995)	Sediment		1	8/19/1993	5/3/1994	2	Dioxins and furans
TCEQ and USEPA (2006)	Sediment		9	7/12/2005	7/13/2005	10	Dioxins and furans Metals PAH PCBs Pesticides Semivolatiles
URS (2010)	Sediment		4	8/20/2009	8/20/2009	5	Dioxins and furans
URS (2010)	Surface water		2	8/20/2009	8/20/2009	3	Dioxins and furans
University of Houston and Parsons (2008)	Sediment		1	5/2/2008	5/2/2008	1	PCBs
Koenig (2010, Pers. Comm.)	Sediment		1	5/6/2009	5/6/2009	1	PCBs
TDSHS (2007)	Edible	Blue crab	2	8/10/1999	4/7/2004	4	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Blue catfish	2	1/13/1999	3/11/2004	3	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Freshwater drum	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles

Table 2-4
Data Sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
TDSHS (2007)	Fillet	hybrid striped bass	2	1/13/1999	3/11/2004	3	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Red drum	1	3/11/2004	3/11/2004	2	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Smallmouth buffalo	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Southern flounder	1	1/13/1999	1/13/1999	1	Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
TDSHS (2007)	Fillet	Spotted seatrout	1	2/10/2004	3/11/2004	2	Dioxins and furans Herbicides Metals PAH PCBs Pesticides Semivolatiles Volatiles
University of Houston and Parsons (2006)	Edible	Blue catfish	1	11/20/2002	3/23/2004	2	Dioxins and furans PCBs Pesticides Physical/chemical parameters

Table 2-4
Data Sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Superfund Site

Study	Sample Material	Common Name	Number of Locations	First Date	Last Date	Number of Samples	Analytes
University of Houston and Parsons (2006)	Edible	Blue crab	1	8/9/2002	10/27/2004	6	Dioxins and furans PCBs Pesticides Physical/chemical parameters
University of Houston and Parsons (2006)	Edible	Hardhead catfish	1	8/9/2002	10/28/2004	4	Dioxins and furans PCBs Physical/chemical parameters
University of Houston and Parsons (2006)	Sediment		24	8/8/2002	8/30/2005	45	Dioxins and furans Grain size PCBs Physical/chemical parameters
University of Houston and Parsons (2006)	Surface water		1	8/7/2002	11/3/2004	22	Dioxins and furans PCBs Physical/chemical parameters
Weston (2006)	Sediment		12	5/10/2006	6/2/2006	54	Dioxins and furans Grain size Metals PAH PCBs Physical/chemical parameters Semivolatiles

Table 2-5

Number of Surface Sediment and Core Sampling Locations by Study

Location[a]	Study	Number of Locations[b]	
		Surface	Core
Site	ENSR and EHA (1995)	1	0
Site	TCEQ and USEPA (2006)	9	0
Site	URS (2010)	4	0
Site	University of Houston and Parsons (2006)	24	1
Site	Weston (2006)	8	4
Nearby Area	ENSR and EHA (1995)	2	0
Nearby Area	Orion (2009)	15	0
Nearby Area	TCEQ and USEPA (2006)	5	0
Nearby Area	University of Houston and Parsons (2006)	4	0

Notes:

a - "Site" is within the preliminary Site perimeter established in the Unilateral Administrative Order; "Nearby Area" is a large area in the San Jacinto River, as shown in Figure 2-2.

b - The number of locations may differ from the number of samples if a location was sampled more than once (Table 2-1).

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Elements									
Aluminum	mg/kg	10	10	100%			6100	13000	22000
Antimony	mg/kg	10	1	10%	3.8	7.2	2.4	2.4	2.4
Arsenic	mg/kg	47	44	94%	1.0	1.4	0.26	3.5	8.6
Barium	mg/kg	47	47	100%			12	110	320
Beryllium	mg/kg	10	2	20%	0.32	#NAME?	0.89	1.1	1.3
Cadmium	mg/kg	47	14	30%	0.016	#NAME?	0.038	0.34	1.1
Calcium	mg/kg	10	10	100%			820	55000	190000
Chromium	mg/kg	47	47	100%			3.1	12	23
Cobalt	mg/kg	10	10	100%			3.1	5.7	13
Copper	mg/kg	10	9	90%	1.6	1.6	8.9	31	62
Iron	mg/kg	10	10	100%			3900	10000	20000
Lead	mg/kg	47	47	100%			3.2	14	59
Magnesium	mg/kg	10	10	100%			1300	3000	4800
Manganese	mg/kg	10	10	100%			58	370	790
Mercury	mg/kg	47	27	57%	0.00080	0.070	0.003	0.25	1.7
Nickel	mg/kg	10	10	100%			4.7	12	20
Potassium	mg/kg	10	8	80%	510	520	900	2100	3100
Selenium	mg/kg	47	36	77%	0.11	4.8	0.25	0.73	2.0
Silver	mg/kg	47	2	4%	0.01	1.4	0.21	0.25	0.29
Sodium	mg/kg	10	10	100%			1200	4100	6800
Thallium	mg/kg	10	1	10%	1.6	3.4	1.3	1.3	1.3
Vanadium	mg/kg	10	10	100%			12	23	49
Zinc	mg/kg	10	10	100%			14	110	240
Physical Properties									
Organic carbon	percent	50	50	100%			0.018	1.1	8.6
Clay	percent	48	48	100%			3	45	88
Gravel	percent	43	23	53%	0	0	0	2.8	13
Sand	percent	49	49	100%			0	23	90
Silt	percent	48	48	100%			6.7	32	63
Dioxins and Furans									
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	98	72	73%	0.0050	0.059	0.22	1500	23000
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	98	79	81%	0.011	130	0.12	23	360
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	98	60	61%	0.0075	70	0.053	1.1	6.2
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	98	67	68%	0.0075	50	0.10	3.0	28
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	98	69	70%	0.0075	170	0.15	2.2	10
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	98	94	96%	0.069	220	0.083	72	1300
Octachlorodibenzo-*p*-dioxin	ng/kg	98	95	97%	170	170	0.49	1600	11000
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	98	71	72%	0.0055	0.42	2.9	4300	93000
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	98	63	64%	0.0055	120	0.10	270	3800
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	98	65	66%	0.0055	180	0.14	180	2300
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	98	65	66%	0.005	55	0.12	520	8700
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	98	64	65%	0.0055	95	0.11	140	2300
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	98	44	45%	0.0070	290	0.26	64	660

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	98	56	57%	0.0060	230	0.090	27	350
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	98	75	77%	0.012	80	0.092	120	2400
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	98	63	64%	0.018	70	0.11	52	880
Octachlorodibenzofuran	ng/kg	98	91	93%	0.020	500	0.065	85	1100
Semivolatile Organic Compounds									
1,1'-Biphenyl	µg/kg	10	0	0%	200	460			
1,2,4-Trichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,2-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,3-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
1,4-Dichlorobenzene	mg/kg	37	0	0%	0.017	0.049			
2,2'-oxybis(1-Chloropropane)	mg/kg	47	0	0%	0.017	0.46			
2,4,5-Trichlorophenol	mg/kg	47	0	0%	0.022	1.2			
2,4,6-Trichlorophenol	mg/kg	47	0	0%	0.022	0.46			
2,4-Dichlorophenol	mg/kg	47	0	0%	0.017	0.46			
2,4-Dimethylphenol	mg/kg	47	0	0%	0.017	0.46			
2,4-Dinitrophenol	mg/kg	47	0	0%	0.017	1.2			
2,4-Dinitrotoluene	mg/kg	47	0	0%	0.017	0.46			
2,6-Dinitrotoluene	mg/kg	47	0	0%	0.017	0.46			
2-Chloronaphthalene	mg/kg	47	0	0%	0.017	0.46			
2-Chlorophenol	mg/kg	47	0	0%	0.017	0.46			
2-Methylnaphthalene	mg/kg	47	0	0%	0.017	0.46			
2-Methylphenol	mg/kg	47	0	0%	0.017	0.46			
2-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
2-Nitrophenol	mg/kg	47	0	0%	0.017	0.46			
3,3'-Dichlorobenzidine	mg/kg	47	0	0%	0.017	0.46			
3,4-Methylphenol	mg/kg	37	0	0%	0.017	0.049			
3-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
4,6-Dinitro-2-methylphenol	mg/kg	47	0	0%	0.028	1.2			
4-Bromophenyl-phenylether	mg/kg	47	0	0%	0.017	0.46			
4-Chloro-3-methylphenol	mg/kg	47	0	0%	0.022	0.46			
4-Chloroaniline	mg/kg	47	0	0%	0.017	0.46			
4-Chlorophenyl-phenyl ether	mg/kg	47	0	0%	0.017	0.46			
4-Methylphenol	µg/kg	10	0	0%	200	460			
4-Nitroaniline	mg/kg	47	0	0%	0.017	1.2			
4-Nitrophenol	mg/kg	47	0	0%	0.055	1.2			
Acenaphthene	mg/kg	47	0	0%	0.017	0.46			
Acenaphthylene	mg/kg	47	0	0%	0.017	0.46			
Acetophenone	µg/kg	10	0	0%	200	460			
Anthracene	mg/kg	47	0	0%	0.017	0.46			
Benzaldehyde	µg/kg	10	0	0%	200	460			
Benzo[a]anthracene	mg/kg	47	0	0%	0.017	0.46			
Benzo[a]pyrene	mg/kg	47	0	0%	0.017	0.46			
Benzo[b]fluoranthene	mg/kg	47	0	0%	0.017	0.46			
Benzo[g,h,i]perylene	mg/kg	47	0	0%	0.017	0.46			

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Benzo[k]fluoranthene	mg/kg	47	0	0%	0.017	0.46			
Benzyl n-butyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Bis(2-chloroethoxy)methane	mg/kg	47	0	0%	0.017	0.46			
Bis(2-chloroethyl)ether	mg/kg	47	0	0%	0.017	0.46			
Bis(2-ethylhexyl)phthalate	mg/kg	47	4	9%	0.017	0.46	0.11	0.56	1.8
Caprolactam	µg/kg	10	0	0%	200	460			
Chrysene	mg/kg	47	0	0%	0.017	0.46			
Dibenzo[a,h]anthracene	mg/kg	47	0	0%	0.017	0.46			
Dibenzofuran	mg/kg	47	0	0%	0.017	0.46			
Diethyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Dimethyl phthalate	mg/kg	47	0	0%	0.017	0.46			
Di-n-butyl phthalate	mg/kg	47	1	2%	0.017	0.46	0.45	0.45	0.45
Di-n-octylphthalate	mg/kg	47	0	0%	0.017	0.46			
Fluoranthene	mg/kg	47	0	0%	0.017	0.46			
Fluorene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorobenzene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorobutadiene	mg/kg	47	0	0%	0.017	0.46			
Hexachlorocyclopentadiene	mg/kg	47	0	0%	0.017	0.46			
Hexachloroethane	mg/kg	47	0	0%	0.017	0.46			
Indeno[1,2,3-cd]pyrene	mg/kg	47	0	0%	0.017	0.46			
Isophorone	mg/kg	47	0	0%	0.017	0.46			
Naphthalene	mg/kg	47	0	0%	0.017	0.46			
Nitrobenzene	mg/kg	47	0	0%	0.017	0.46			
N-Nitrosodi-n-propylamine	mg/kg	47	0	0%	0.017	0.46			
N-Nitrosodiphenylamine	mg/kg	47	0	0%	0.017	0.46			
Pentachlorophenol	mg/kg	47	0	0%	0.028	1.2			
Phenanthrene	mg/kg	47	0	0%	0.017	0.46			
Phenol	mg/kg	47	0	0%	0.040	0.46			
Pyrene	mg/kg	47	0	0%	0.017	0.46			
Pesticides									
4,4'-DDD	µg/kg	10	0	0%	2.0	4.5			
4,4'-DDE	µg/kg	10	0	0%	2.0	4.5			
4,4'-DDT	µg/kg	10	0	0%	2.0	4.5			
Aldrin	µg/kg	10	0	0%	1.0	2.4			
Atrazine	µg/kg	10	0	0%	200	460			
alpha-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
beta-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
delta-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
gamma-Benzenehexachloride	µg/kg	10	0	0%	1.0	2.4			
Carbazole	mg/kg	47	0	0%	0.017	0.46			
cis-Chlordane	µg/kg	10	0	0%	1.0	2.4			
Dieldrin	µg/kg	10	0	0%	2.0	4.5			
Endosulfan I	µg/kg	10	0	0%	1.0	2.4			
Endosulfan II	µg/kg	10	0	0%	2.0	4.5			

Table 2-6
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples from the Site

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Endosulfan sulfate	µg/kg	10	0	0%	2.0	4.5			
Endrin	µg/kg	10	0	0%	2.0	4.5			
Endrin aldehyde	µg/kg	10	0	0%	2.0	4.5			
Endrin ketone	µg/kg	10	0	0%	2.0	4.5			
Heptachlor	µg/kg	10	0	0%	1.0	2.4			
Heptachlor epoxide	µg/kg	10	0	0%	1.0	2.4			
Methoxychlor	µg/kg	10	0	0%	10	24			
Toxaphene	µg/kg	10	0	0%	100	240			
trans-Chlordane	µg/kg	10	0	0%	1.0	2.4			
Polychlorinated Biphenyls									
Aroclor 1016	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1221	mg/kg	47	0	0%	0.0017	0.090			
Aroclor 1232	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1242	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1248	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1254	mg/kg	47	0	0%	0.0017	0.046			
Aroclor 1260	mg/kg	47	0	0%	0.0012	0.046			

Notes:
All concentrations are on a dry-weight basis.

Table 2-7
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Elements									
Aluminum	mg/kg	2	2	100%			2200	2500	2800
Antimony	mg/kg	2	0	0%	3.7	3.8			
Arsenic	mg/kg	2	0	0%	0.60	0.65			
Barium	mg/kg	2	0	0%	12	13			
Beryllium	mg/kg	2	0	0%	0.31	0.32			
Cadmium	mg/kg	2	0	0%	0.31	0.32			
Calcium	mg/kg	2	1	50%	100	100	620	620	620
Chromium	mg/kg	2	2	100%			3.2	3.6	3.9
Cobalt	mg/kg	2	2	100%			1.1	1.3	1.5
Copper	mg/kg	2	2	100%			1.4	1.9	2.4
Iron	mg/kg	2	2	100%			1800	2200	2600
Lead	mg/kg	2	2	100%			2.5	2.7	2.9
Magnesium	mg/kg	2	1	50%	320	320	730	730	730
Manganese	mg/kg	2	2	100%			12	22	33
Mercury	mg/kg	2	0	0%	0.060	0.060			
Nickel	mg/kg	2	2	100%			1.7	2.0	2.3
Potassium	mg/kg	2	0	0%	310	320			
Selenium	mg/kg	2	0	0%	2.2	2.2			
Silver	mg/kg	2	0	0%	0.60	0.65			
Sodium	mg/kg	2	2	100%			720	780	840
Thallium	mg/kg	2	0	0%	1.6	1.6			
Vanadium	mg/kg	2	2	100%			4.3	4.8	5.3
Zinc	mg/kg	2	2	100%			6.0	7.5	8.9
Physical Properties									
Organic carbon	percent	7	7	100%			0.26	0.90	1.4
Clay	percent	7	7	100%			8.6	19	42
Gravel	percent	3	3	100%			0	0.033	0.10
Sand	percent	7	7	100%			10	46	72
Silt	percent	7	7	100%			19	35	64
Dioxins and Furans									
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	23	22	96%	0.12	0.12	0.47	17	33
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	23	19	83%	0.058	2.0	0.20	1.0	1.5
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	23	18	78%	0.30	2.1	0.30	1.5	2.3
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	23	21	91%	0.60	1.6	0.46	3.6	5.7
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	23	20	87%	0.29	1.5	0.58	4.5	7.8
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	23	23	100%			11	120	190
Octachlorodibenzo-*p* -dioxin	pg/g	23	23	100%			390	3600	7300
2,3,7,8-Tetrachlorodibenzofuran	pg/g	23	22	96%	0.13	0.13	1.1	36	64
1,2,3,7,8-Pentachlorodibenzofuran	pg/g	23	17	74%	0.23	1.4	0.24	2.0	2.8
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	23	19	83%	0.14	1.2	0.2	1.9	2.8
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	23	18	78%	0.26	1.3	0.11	3.3	4.9
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	23	19	83%	0.14	1.2	0.16	1.6	2.9
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	23	15	65%	0.065	1.2	0.12	0.64	0.89

Table 2-7
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	23	17	74%	0.025	1.4	0.56	1.4	1.9
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	23	21	91%	0.24	1.2	1.0	18	30
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	23	17	74%	0.055	2.1	0.12	2.0	3.7
Octachlorodibenzofuran	pg/g	23	23	100%			3.3	230	610
Semivolatile Organic Compounds									
1,1'-Biphenyl	µg/kg	2	0	0%	220	220			
2-Methylnaphthalene	µg/kg	2	0	0%	220	220			
2-Nitroaniline	µg/kg	2	0	0%	550	550			
3-Nitroaniline	µg/kg	2	0	0%	550	550			
4-Nitroaniline	µg/kg	2	0	0%	550	550			
Acenaphthene	µg/kg	2	0	0%	220	220			
Acenaphthylene	µg/kg	2	0	0%	220	220			
Anthracene	µg/kg	2	0	0%	220	220			
Benzo[a]anthracene	µg/kg	2	0	0%	220	220			
Benzo[a]pyrene	µg/kg	2	0	0%	220	220			
Benzo[b]fluoranthene	µg/kg	2	0	0%	220	220			
Benzo[g,h,i]perylene	µg/kg	2	0	0%	220	220			
Benzo[k]fluoranthene	µg/kg	2	0	0%	220	220			
Chrysene	µg/kg	2	0	0%	220	220			
Dibenzo[a,h]anthracene	µg/kg	2	0	0%	220	220			
Dibenzofuran	µg/kg	2	0	0%	220	220			
Fluoranthene	µg/kg	2	0	0%	220	220			
Fluorene	µg/kg	2	0	0%	220	220			
Indeno[1,2,3-cd]pyrene	µg/kg	2	0	0%	220	220			
Naphthalene	µg/kg	2	0	0%	220	220			
Phenanthrene	µg/kg	2	0	0%	220	220			
Pyrene	µg/kg	2	0	0%	220	220			
2,2'-Oxybis(1-chloropropane)	µg/kg	2	0	0%	220	220			
2,4,5-Trichlorophenol	µg/kg	2	0	0%	550	550			
2,4,6-Trichlorophenol	µg/kg	2	0	0%	220	220			
2,4-Dichlorophenol	µg/kg	2	0	0%	220	220			
2,4-Dimethylphenol	µg/kg	2	0	0%	220	220			
2,4-Dinitrophenol	µg/kg	2	0	0%	550	550			
2,4-Dinitrotoluene	µg/kg	2	0	0%	220	220			
2,6-Dinitrotoluene	µg/kg	2	0	0%	220	220			
2-Chloronaphthalene	µg/kg	2	0	0%	220	220			
2-Chlorophenol	µg/kg	2	0	0%	220	220			
2-Methylphenol	µg/kg	2	0	0%	220	220			
2-Nitrophenol	µg/kg	2	0	0%	220	220			
3,3'-Dichlorobenzidine	µg/kg	2	0	0%	220	220			
4,6-Dinitro-2-methylphenol	µg/kg	2	0	0%	550	550			
4-Bromophenyl-phenylether	µg/kg	2	0	0%	220	220			
4-Chloro-3-methylphenol	µg/kg	2	0	0%	220	220			
4-Chloroaniline	µg/kg	2	0	0%	220	220			

Table 2-7
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
4-Chlorophenyl-phenyl ether	µg/kg	2	0	0%	220	220			
4-Methylphenol	µg/kg	2	0	0%	220	220			
4-Nitrophenol	µg/kg	2	0	0%	550	550			
Acetophenone	µg/kg	2	0	0%	220	220			
Benzaldehyde	µg/kg	2	0	0%	220	220			
Benzyl n-butyl phthalate	µg/kg	2	0	0%	220	220			
Bis(2-chloroethoxy)methane	µg/kg	2	0	0%	220	220			
Bis(2-ethylhexyl)phthalate	µg/kg	2	0	0%	220	220			
Caprolactam	µg/kg	2	0	0%	220	220			
Diethyl phthalate	µg/kg	2	0	0%	220	220			
Dimethyl phthalate	µg/kg	2	0	0%	220	220			
Di-n-butyl phthalate	µg/kg	2	0	0%	220	220			
Di-n-octylphthalate	µg/kg	2	0	0%	220	220			
Hexachlorobenzene	µg/kg	2	0	0%	220	220			
Hexachlorobutadiene	µg/kg	2	0	0%	220	220			
Hexachlorocyclopentadiene	µg/kg	2	0	0%	220	220			
Hexachloroethane	µg/kg	2	0	0%	220	220			
Isophorone	µg/kg	2	0	0%	220	220			
Nitrobenzene	µg/kg	2	0	0%	220	220			
N-Nitrosodi-n-propylamine	µg/kg	2	0	0%	220	220			
N-Nitrosodiphenylamine	µg/kg	2	0	0%	220	220			
Pentachlorophenol	µg/kg	2	0	0%	550	550			
Phenol	µg/kg	2	0	0%	220	220			
Bis(2-chloroethyl)ether	µg/kg	2	0	0%	220	220			
Pesticides									
4,4'-DDD	µg/kg	2	2	100%			7.7	16	25
4,4'-DDE	µg/kg	2	0	0%	2.2	2.2			
4,4'-DDT	µg/kg	2	2	100%			14	36	57
Aldrin	µg/kg	2	1	50%	1.1	1.1	0.70	0.70	0.70
alpha-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Atrazine	µg/kg	2	0	0%	220	220			
beta-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Carbazole	µg/kg	2	0	0%	220	220			
cis-Chlordane	µg/kg	2	0	0%	1.1	1.1			
delta-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Dieldrin	µg/kg	2	0	0%	2.2	2.2			
Endosulfan I	µg/kg	2	0	0%	1.1	1.1			
Endosulfan II	µg/kg	2	0	0%	2.2	2.2			
Endosulfan sulfate	µg/kg	2	0	0%	2.2	2.2			
Endrin	µg/kg	2	0	0%	2.2	2.2			
Endrin aldehyde	µg/kg	2	0	0%	2.2	2.2			
Endrin ketone	µg/kg	2	0	0%	2.2	2.2			
gamma-Benzenehexachloride	µg/kg	2	0	0%	1.1	1.1			
Heptachlor	µg/kg	2	0	0%	1.1	1.1			

Table 2-7
Detection Frequencies and Summary Statistics for Analytes in Sediment Samples Within the Nearby Area But Outside the Preliminary Site Perimeter

Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
					Minimum	Maximum	Minimum	Mean	Maximum
Heptachlor epoxide	µg/kg	2	0	0%	1.1	1.1			
Methoxychlor	µg/kg	2	0	0%	11	11			
Toxaphene	µg/kg	2	0	0%	110	110			
trans-Chlordane	µg/kg	2	1	50%	1.1	1.1	1.2	1.2	1.2
Polychlorinated Biphenyls									
Aroclor 1016	µg/kg	2	0	0%	22	22			
Aroclor 1221	µg/kg	2	0	0%	43	44			
Aroclor 1232	µg/kg	2	0	0%	22	22			
Aroclor 1242	µg/kg	2	0	0%	22	22			
Aroclor 1248	µg/kg	2	0	0%	22	22			
Aroclor 1254	µg/kg	2	0	0%	22	22			
Aroclor 1260	µg/kg	2	0	0%	22	22			

Notes:

All concentrations are on a dry-weight basis.

Table 2-8
Detection Frequencies and Summary Statistics for Dioxins and Furans in Surface Water Samples from the Site

Analyte	Measurement basis	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits (pg/L)		Detected Data (pg/L)		
					Minimum	Maximum	Minimum	Mean	Maximum
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	Total	3	3	100%			1.9	5.5	7.5
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.65	0.70			
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.60	0.70			
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.70	0.80			
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	Total	3	0	0%	0.55	0.85			
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	Total	3	0	0%	2.6	3.4			
Octachlorodibenzo-*p* -dioxin	Total	3	0	0%	70	80			
2,3,7,8-Tetrachlorodibenzofuran	Total	3	3	100%			9.1	22	30
1,2,3,7,8-Pentachlorodibenzofuran	Total	3	2	67%	0.65	0.65	1.9	2.4	2.9
2,3,4,7,8-Pentachlorodibenzofuran	Total	3	2	67%	0.46	0.46	1.9	1.9	1.9
1,2,3,4,7,8-Hexachlorodibenzofuran	Total	3	3	100%			1.2	6.3	12
1,2,3,6,7,8-Hexachlorodibenzofuran	Total	3	2	67%	0.55	0.55	1.8	2.5	3.1
1,2,3,7,8,9-Hexachlorodibenzofuran	Total	3	0	0%	0.55	0.70			
2,3,4,6,7,8-Hexachlorodibenzofuran	Total	3	0	0%	0.46	0.65			
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Total	3	2	67%	0.80	0.80	3.4	4.3	5.1
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Total	3	0	0%	1.3	1.5			
Octachlorodibenzofuran	Total	3	2	67%	4.4	4.4	8.9	11	13
2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	Dissolved	9	7	78%	10	12	27	84	130
1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	Dissolved	9	1	11%	1.7	3.8	5.1	5.1	5.1
1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	2.3	7.0	2.9	6.1	9.5
1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	3.0	7.0	5.8	11	14
1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	Dissolved	9	6	67%	2.9	7.0	8.7	15	20
1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	Dissolved	9	8	89%	60	60	91	300	490
Octachlorodibenzo-*p* -dioxin	Dissolved	9	9	100%			2500	9600	19000
2,3,7,8-Tetrachlorodibenzofuran	Dissolved	9	9	100%			74	260	480
1,2,3,7,8-Pentachlorodibenzofuran	Dissolved	9	5	56%	1.2	10	6.4	9.3	13
2,3,4,7,8-Pentachlorodibenzofuran	Dissolved	9	5	56%	2.8	9.0	5.7	8.1	9.5
1,2,3,4,7,8-Hexachlorodibenzofuran	Dissolved	9	5	56%	2.4	38	12	17	24
1,2,3,6,7,8-Hexachlorodibenzofuran	Dissolved	9	4	44%	1.6	8.5	4.3	5.7	6.4
1,2,3,7,8,9-Hexachlorodibenzofuran	Dissolved	9	0	0%	1.0	4.5			
2,3,4,6,7,8-Hexachlorodibenzofuran	Dissolved	9	4	44%	1.0	4.1	3.1	3.9	5.2
1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dissolved	9	4	44%	7.0	28	28	38	55
1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dissolved	9	4	44%	1.4	9.5	4.3	6.5	9.1
Octachlorodibenzofuran	Dissolved	9	9	100%			81	210	610

Notes:
All data were collected within the preliminary site perimeter (TCEQ 2009).

Table 2-9
TCDD and TCDF Concentrations in Surface Water Samples from the Site

Location	Sample Date	Measurement Basis	2,3,7,8-TCDD (pg/L)		2,3,7,8-TCDF (pg/L)	
11193	8/7/2002	Dissolved	12	*U*	110	
11193	11/20/2002	Dissolved	46		200	
11193	6/4/2003	Dissolved	120		410	
11193	3/23/2004	Dissolved	96		320	*J*
11193	3/23/2004	Dissolved	90		300	*J*
11193	8/3/2004	Dissolved	82		370	
11193	8/3/2004	Dissolved	130		480	
11193	11/3/2004	Dissolved	27		78	
11193	11/3/2004	Dissolved	10	*UJ*	74	
TCEQ2009_01	8/20/2009	Total	7.0	*J*	27	
TCEQ2009_01	8/20/2009	Total	7.5	*J*	30	
TCEQ2009_03	8/20/2009	Total	1.9	*J*	9.1	*J*

Notes:
J = estimated
U = undetected
TCDD = tetrachlorodibenzo-*p* -dioxin
TCDF = tetrachlorodibenzofuran

Table 2-10
Dissolved TCDD and TCDF Concentrations in Upstream Surface Water Samples

Location ID	Sample Date	2,3,7,8-TCDD (pg/L, dissolved)		2,3,7,8-TCDF (pg/L, dissolved)	
11200	9/2/2002	1.4	*U*	9.2	*J*
16622	9/2/2002	1.4	*U*	11	*J*
11200	11/21/2002	1.9	*U*	8	*J*
16622	6/3/2003	2.7	*U*	22	
11197	3/24/2004	3.8	*U*	29	
11197	10/29/2004	6.0	*UJ*	38	

Notes:

Data are from the Total Maximum Daily Load program (University of Houston and Parsons 2006).

J = estimated
U = undetected
TCDD = tetrachlorodibenzo-*p*-dioxin
TCDF = tetrachlorodibenzofuran

Table 2-11
Ambient Air Sampling Event

Event	Number of Locations	Sampling Dates	Type of Samples Collected	Blank
September/02	3	09/01/02-09/27/02	T (4)	T(1)
October /02	5	10/12/02-11/01/02	T(5), P(2), G(2)	T(1)
November /02	4	11/09/02-11/29/02	T(4),P(1), G(1)	T(1)
December/02	4	11/30/02-12/20/02	T(5)	P(1), G(1)
January/03	4	01/11/03-01/30/02	T(4), P(2), G(2)	T(1)
February/03	4	02/01/03-02/27/03	T(4), P(2), G(2)	T(1)
March/03	5	03/08/03-04/03/03	T (5), P(2), G(2)	T(1)
April/03	5	04/05/03-05/01/03	T(5), P(2), G(2)	T(1)
May/03	5	05/03/03-05/28/03	T(5), P(2), G(2)	T(1)
June/03	5	05/31/03-06/26/03	T(5), P(2), G(2)	T(1)
July/03	5	06/30/03-07/28/03	T(5), P(2), G(2)	T(1)
August/03	5	08/02/03-08/28/03	T(5), P(2), G(2)	T(1)
December/03-January/04	2	12/13/03-01/09/04	T(2), P(2), G(2), DD(2)	T(1), DD(1)
January/04-February/04	2	01/17/04-02/20/04	T(2), P(2), G(2), DD(1)	T(1), DD(1)
February/04-March/04	2	02/27/04-03/26/04	P(2), G(2), DD(2)	T(1)
March/04-April/04	2	03/26/04-04/23/04	P(2), G(2), DD(2), WD(1)	
September/04-October/04	1	09/07/04-11/02/04	P(1), G(1), DD(1), PSD(6)	
November /04-December/04	1	11/03/04-12/28/04	P(1), G(1), DD(1), PSD(6)	
January/05-February/05	1	12/28/04-202/22/05	P(1), G(1), DD(1), WD(1), BD(1), PSD(6)	T(1), PSD(3)
June/05-May/06	1	06/08/05-05/09/06	P(1), G(1), DD(1), WD(1), BD(1)	T(1)
Numbers in parenthesis correspond to the number of samples collected.				
T - Total ambient air				
P - Particle phase				
G - Gas phase				
DD - Dry deposition				
WD - Wet deposition				
BD - Bulk deposition				
PSD - Particle size distribution				

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
Blue Catfish / Edible / Physical and Chemical										
	Lipid	percent	2	2	100%			0.80	1.6	2.4
Blue Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	2	2	100%			4.3	4.5	4.6
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	2	2	100%			0.27	0.28	0.29
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	2	0	0%	0.070	0.090			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	2	2	100%			0.40	0.42	0.43
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	2	2	100%			0.23	0.30	0.37
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	2	1	50%	0.41	0.41	1.5	1.5	1.5
	Octachlorodibenzo-*p* -dioxin	ng/kg	2	2	100%			3.6	5.3	7.0
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	2	2	100%			4.3	4.5	4.6
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	2	2	100%			0.27	0.28	0.29
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	2	2	100%			0.63	0.71	0.79
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	2	2	100%			0.62	1.4	2.2
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	2	1	50%	0.095	0.095	0.29	0.29	0.29
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	2	2	100%			0.37	0.39	0.41
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	2	2	100%			0.13	0.39	0.64
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.090	0.090	0.12	0.12	0.12
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.085	0.085	0.10	0.10	0.10
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	2	2	100%			0.088	0.26	0.44
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	2	1	50%	0.13	0.13	0.11	0.11	0.11
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	2	0	0%	0.18	0.38			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	2	0	0%	0.090	0.20			
	Octachlorodibenzofuran	ng/kg	2	2	100%			0.91	1.2	1.4
	Tetrachlorodibenzofuran (Total)	ng/kg	2	2	100%			0.24	0.27	0.29
	Pentachlorodibenzofuran (Total)	ng/kg	2	2	100%			1.1	2.8	4.5
	Hexachlorodibenzofuran (Total)	ng/kg	2	2	100%			0.33	1.1	1.9
	Heptachlorodibenzofuran (Total)	ng/kg	2	1	50%	0.43	0.43	0.41	0.41	0.41
Blue Catfish / Edible / Pesticides										
	Dieldrin	mg/kg	1	0	0%	0.0030	0.0030			
	Heptachlor epoxide	mg/kg	1	0	0%	0.0015	0.0015			
	sum of p,p'-DDD and o,p'-DDD	mg/kg	1	0	0%	0.0030	0.0030			
	sum of p,p'-DDE and o,p'-DDE	mg/kg	1	1	100%			0.0070	0.0070	0.0070
Blue Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Blue Catfish / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.014	0.031			
	Cadmium	mg/kg	2	0	0%	0.0070	0.0076			
	Copper	mg/kg	2	2	100%			0.19	0.20	0.21
	Lead	mg/kg	2	1	50%	0.018	0.018	0.073	0.073	0.073
	Mercury	mg/kg	2	2	100%			0.076	0.10	0.13
	Selenium	mg/kg	2	2	100%			0.23	0.24	0.25
	Zinc	mg/kg	2	2	100%			3.9	4.0	4.2
Blue Catfish / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			2.8	5.4	8.1
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.041	0.21			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.025	0.028			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			0.39	0.81	1.2
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	2	1	50%	0.060	0.060	0.43	0.43	0.43
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			0.98	1.3	1.6
	Octachlorodibenzo-*p* -dioxin	pg/g	2	2	100%			1.3	2.2	3.0
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	2	100%			0.67	1.1	1.5
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	1	50%	0.027	0.027	0.17	0.17	0.17
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	2	100%			0.22	0.43	0.64
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.026	0.041			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.023	0.040			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.033	0.042			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.025	0.042			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.036	0.055			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.048	0.055			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.028	0.036			
Blue Catfish / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	1	100%			360	360	360
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Blue Catfish / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	1	50%	0.0050	0.0050	0.012	0.012	0.012
	4,4'-DDE	mg/kg	2	1	50%	0.0025	0.0025	0.0055	0.0055	0.0055
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			36	36	36
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	0	0%	0.0020	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Blue Catfish / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Blue Catfish / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	1	50%	20	20	52	52	52
Blue Crab / Edible / Metals										
	Arsenic	mg/kg	2	0	0%	0.012	0.014			
	Cadmium	mg/kg	2	1	50%	0.0060	0.0060	0.025	0.025	0.025
	Copper	mg/kg	2	2	100%			7.7	8.1	8.5
	Lead	mg/kg	2	0	0%	0.015	0.023			
	Mercury	mg/kg	2	2	100%			0.078	0.078	0.078
	Selenium	mg/kg	2	2	100%			0.90	0.92	0.94
	Zinc	mg/kg	2	2	100%			30	30	31
Blue Crab / Edible / Physical and Chemical										
	Lipid	percent	6	6	100%			0.70	0.95	1.1
Blue Crab / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	8	7	88%	0.80	0.80	2.4	4.7	11
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	8	3	38%	0.025	0.17	0.12	0.15	0.18
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	8	4	50%	0.085	0.12	0.25	0.44	0.56
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	8	1	13%	0.027	0.13	0.21	0.21	0.21
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	8	3	38%	0.030	0.14	0.21	0.23	0.24
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	8	3	38%	0.028	0.13	0.18	0.20	0.23
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	8	7	88%	0.14	0.14	0.44	0.77	1.4
	Octachlorodibenzo-*p*-dioxin	ng/kg	8	8	100%			1.6	5.3	15

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	5	83%	0.80	0.80	3.6	6.7	12
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	4	67%	0.080	0.17	0.29	0.65	0.99
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	6	100%			0.37	1.8	3.2
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	6	6	100%			1.3	1.8	2.3
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	8	8	100%			3.3	10	29
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	8	3	38%	0.029	0.12	0.18	0.37	0.49
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	8	2	25%	0.024	0.090	0.14	0.15	0.16
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	8	1	13%	0.022	0.29	0.11	0.11	0.11
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	8	1	13%	0.031	0.17	0.21	0.21	0.21
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	8	2	25%	0.024	0.12	0.13	0.19	0.24
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	8	3	38%	0.060	0.13	0.25	0.34	0.50
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	8	0	0%	0.032	0.15			
	Octachlorodibenzofuran	ng/kg	8	5	63%	0.032	0.15	0.51	1.1	2.0
	Tetrachlorodibenzofuran (Total)	ng/kg	6	6	100%			4.1	18	38
	Pentachlorodibenzofuran (Total)	ng/kg	6	6	100%			0.54	2.3	5.0
	Hexachlorodibenzofuran (Total)	ng/kg	6	5	83%	0.45	0.45	0.33	0.71	1.2
	Heptachlorodibenzofuran (Total)	ng/kg	6	4	67%	0.075	0.095	0.32	0.65	1.1
Blue Crab / Edible / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	1	100%			65	65	65
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Blue Crab / Edible / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	4,4'-DDE	mg/kg	2	0	0%	0.0025	0.0025			
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			13	17	21
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	3	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	3	0	0%	0.0015	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	sum of p,p'-DDD and o,p'-DDD	mg/kg	1	0	0%	0.0030	0.0030			
	sum of p,p'-DDE and o,p'-DDE	mg/kg	1	0	0%	0.0020	0.0020			
	sum of p,p'-DDT and o,p'-DDT	mg/kg	1	0	0%	0.0045	0.0045			
	Toxaphene	µg/kg	2	0	0%	50	50			
Blue Crab / Edible / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Blue Crab / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1221	mg/kg	4	0	0%	0.0075	0.020			
	Aroclor 1232	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1242	mg/kg	4	0	0%	0.019	0.020			
	Aroclor 1248	mg/kg	4	0	0%	0.011	0.020			
	Aroclor 1254	mg/kg	4	0	0%	0.020	0.030			
	Aroclor 1260	mg/kg	4	0	0%	0.016	0.020			
	Total PCBs	mg/kg	2	0	0%	0.030	0.030			
Hardhead Catfish / Edible / Physical and Chemical										
	Lipid	percent	4	4	100%			0.40	2.4	3.5
Hardhead Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			5.1	11	14
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.35	0.43	0.50
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.21	0.31	0.41
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	1	25%	0.26	0.48	0.86	0.86	0.86
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	ng/kg	4	3	75%	0.17	0.17	0.29	0.33	0.38
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			0.73	1.1	1.4
	Octachlorodibenzo-*p* -dioxin	ng/kg	4	4	100%			2.4	3.0	3.6
	Tetrachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			5.1	11	14
	Pentachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.35	0.43	0.50
	Hexachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	4	100%			0.31	0.80	1.7

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Heptachlorodibenzo-*p* -dioxin (Total)	ng/kg	4	3	75%	0.80	0.80	0.73	1.0	1.4
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	4	100%			0.18	0.76	1.1
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	2	50%	0.055	0.18	0.19	0.23	0.26
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	4	100%			0.55	0.66	0.75
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.060	0.15			
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.055	2.9	0.19	0.21	0.22
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.085	0.21	0.13	0.13	0.13
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.090	0.11	0.27	0.27	0.27
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.13	0.20			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.080	0.29			
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.50	0.85	1.3
	Tetrachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.18	0.76	1.1
	Pentachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.83	5.4	18
	Hexachlorodibenzofuran (Total)	ng/kg	4	3	75%	3.4	3.4	0.24	0.35	0.45
	Heptachlorodibenzofuran (Total)	ng/kg	4	1	25%	0.18	1.8	0.17	0.17	0.17
Hardhead Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Hybrid Striped Bass / Fillet / Metals										
	Arsenic	mg/kg	1	0	0%	0.025	0.025			
	Cadmium	mg/kg	1	0	0%	0.0072	0.0072			
	Copper	mg/kg	1	1	100%			0.21	0.21	0.21
	Lead	mg/kg	1	0	0%	0.017	0.017			
	Mercury	mg/kg	1	1	100%			0.43	0.43	0.43
	Selenium	mg/kg	1	1	100%			0.55	0.55	0.55
	Zinc	mg/kg	1	1	100%			2.7	2.7	2.7
Hybrid Striped Bass / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			0.59	0.59	0.59
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	1	0	0%	0.30	0.30			
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	1	0	0%	0.15	0.15			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			1.2	1.2	1.2
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			0.31	0.31	0.31
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			1.1	1.1	1.1
	Octachlorodibenzo-*p* -dioxin	pg/g	1	1	100%			4.2	4.2	4.2
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	1	1	100%			3.5	3.5	3.5
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	1	0	0%	0.16	0.16			
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	1	0	0%	0.22	0.22			
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.055	0.055			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.048	0.048			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	1	0	0%	0.065	0.065			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	1	0	0%	0.055	0.055			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	1	0	0%	0.042	0.042			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	1	0	0%	0.032	0.032			
	Octachlorodibenzofuran	pg/g	1	0	0%	0.032	0.032			
Hybrid Striped Bass / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	1	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Hybrid Striped Bass / Fillet / Pesticides										
	4,4'-DDD	mg/kg	1	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	1	1	100%			0.0053	0.0053	0.0053
	4,4'-DDT	mg/kg	1	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	1	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	1	1	100%			76	76	76
	Chlorpyrifos	µg/kg	1	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	1	0	0%	5.0	5.0			
	Dieldrin	mg/kg	1	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	1	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	1	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	1	0	0%	0.0050	0.0050			
	Endrin	mg/kg	1	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	1	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	1	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	1	0	0%	0.0020	0.0020			
	Malathion	µg/kg	1	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Methoxychlor	µg/kg	1	0	0%	15	15			
	Methyl parathion	µg/kg	1	0	0%	5.0	5.0			
	Mirex	µg/kg	1	0	0%	4.0	4.0			
	Parathion	µg/kg	1	0	0%	5.0	5.0			
	Toxaphene	µg/kg	1	0	0%	50	50			
Hybrid Striped Bass / Fillet / Herbicides										
	Alachlor	µg/kg	1	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	1	0	0%	1.5	1.5			
Hybrid Striped Bass / Fillet / Polychorinated Biphenyls										
	Aroclor 1016	µg/kg	1	0	0%	20	20			
	Aroclor 1221	µg/kg	1	0	0%	20	20			
	Aroclor 1232	µg/kg	1	0	0%	20	20			
	Aroclor 1242	µg/kg	1	0	0%	20	20			
	Aroclor 1248	µg/kg	1	0	0%	20	20			
	Aroclor 1254	µg/kg	1	0	0%	20	20			
	Aroclor 1260	µg/kg	1	0	0%	20	20			
Red Drum / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.014	0.028			
	Cadmium	mg/kg	2	0	0%	0.0068	0.0071			
	Copper	mg/kg	2	2	100%			0.16	0.16	0.17
	Lead	mg/kg	2	0	0%	0.016	0.034			
	Mercury	mg/kg	2	2	100%			0.10	0.15	0.20
	Selenium	mg/kg	2	2	100%			0.65	0.85	1.1
	Zinc	mg/kg	2	2	100%			2.4	2.4	2.5
Red Drum / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.026	0.026			
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.032	0.034			
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.029	27			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.028	0.060			
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.028	0.031			
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.030	0.049			
	Octachlorodibenzo-*p* -dioxin	pg/g	2	1	50%	0.027	0.027	1.2	1.2	1.2
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	0	0%	0.049	0.13			
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.028	0.028			
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.026	0.026			
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.027	0.028			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.024	0.026			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.033	0.034			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.026	0.030			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.021	0.038			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.033	0.035			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.030	0.042			
Red Drum / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	2	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	2	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	2	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	2	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	2	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	2	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	2	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	2	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	2	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	2	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,2,4-Trichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	2	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	2	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	2	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	2	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	2	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	2	0	0%	10	10			
	1,3-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	2	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	2	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	2	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	2	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	2	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	2	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	2	0	0%	0.50	0.50			
	2-Butanone	µg/kg	2	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	2	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	2	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	2	0	0%	10	10			
	2-Hexanone	µg/kg	2	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	2	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	2	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	2	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	2	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	2	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	2	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	2	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	2	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	2	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	2	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	2	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	2	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	2	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	2	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	2	0	0%	10	10			
	4-Nitroaniline	mg/kg	2	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	2	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	2	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	2	0	0%	0.20	0.20			
	Acetone	µg/kg	2	0	0%	100	100			
	Acrylonitrile	µg/kg	2	0	0%	10	10			
	Aniline	mg/kg	2	0	0%	2.0	2.0			
	Anthracene	mg/kg	2	0	0%	0.20	0.20			
	Benzene	µg/kg	2	0	0%	10	10			
	Benzidine	mg/kg	2	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	2	0	0%	0.20	0.20			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Benzo[k]fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	2	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	2	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	2	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	2	0	0%	0.50	0.50			
	Bis(2-ethylhexyl)phthalate	mg/kg	2	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	2	0	0%	10	10			
	Bromochloromethane	µg/kg	2	0	0%	10	10			
	Bromodichloromethane	µg/kg	2	0	0%	10	10			
	Bromoform	µg/kg	2	0	0%	10	10			
	Bromomethane	µg/kg	2	0	0%	25	25			
	Carbon disulfide	µg/kg	2	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	2	0	0%	10	10			
	Chlorobenzene	µg/kg	2	0	0%	10	10			
	Chloroethane	µg/kg	2	0	0%	25	25			
	Chloroform	µg/kg	2	0	0%	10	10			
	Chloromethane	µg/kg	2	0	0%	25	25			
	Chrysene	mg/kg	2	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	2	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	2	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	2	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	2	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	2	0	0%	10	10			
	Dibromomethane	µg/kg	2	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	2	0	0%	25	25			
	Diethyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	2	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	2	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	2	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	2	0	0%	10	10			
	Ethylbenzene	µg/kg	2	0	0%	10	10			
	Fluoranthene	mg/kg	2	0	0%	0.20	0.20			
	Fluorene	mg/kg	2	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	0	0%	0.0010	0.0010			
	Hexachlorobutadiene	mg/kg	2	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	2	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	2	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	2	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	2	0	0%	0.20	0.20			
	Iodomethane	µg/kg	2	0	0%	25	25			
	Isophorone	mg/kg	2	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	2	0	0%	10	10			
	m,p-Xylene	µg/kg	2	0	0%	20	20			
	Methyl methacrylate	µg/kg	2	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	2	0	0%	10	10			
	Methylene Chloride	µg/kg	2	0	0%	25	25			
	Naphthalene	mg/kg	2	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	2	0	0%	10	10			
	Nitrobenzene	mg/kg	2	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	N-nitroso diethylamine	mg/kg	2	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	2	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	2	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	2	0	0%	10	10			
	o-Xylene	µg/kg	2	0	0%	10	10			
	Pentachlorophenol	mg/kg	2	0	0%	1.0	1.0			
	Phenanthrene	mg/kg	2	0	0%	0.20	0.20			
	Phenol	mg/kg	2	0	0%	0.50	0.50			
	Pyrene	mg/kg	2	0	0%	0.20	0.20			
	Pyridine	mg/kg	2	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	2	0	0%	10	10			
	Styrene	µg/kg	2	0	0%	10	10			
	tert-Butylbenzene	µg/kg	2	0	0%	10	10			
	Tetrachloroethene	µg/kg	2	0	0%	10	10			
	Tetrahydrofuran	µg/kg	2	0	0%	25	25			
	Toluene	µg/kg	2	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	2	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	2	0	0%	50	50			
	Trichloroethene	µg/kg	2	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	2	0	0%	25	25			
	Vinyl Chloride	µg/kg	2	0	0%	25	25			
Red Drum / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	2	0	0%	0.0025	0.0025			
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	0	0%	5.0	5.0			
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	2	0	0%	0	0			
	Endrin ketone	mg/kg	2	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	0	0%	0.0020	0.0020			
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Red Drum / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
Red Drum / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	0	0%	20	20			
Spotted Seatrout / Fillet / Metals										
	Arsenic	mg/kg	2	0	0%	0.013	0.030			
	Cadmium	mg/kg	2	0	0%	0.0067	0.0070			
	Copper	mg/kg	2	0	0%	0.069	0.071			
	Lead	mg/kg	2	0	0%	0.017	0.13			
	Mercury	mg/kg	2	2	100%			0.20	0.21	0.22
	Selenium	mg/kg	2	2	100%			1.4	1.4	1.4
	Zinc	mg/kg	2	2	100%			2.1	2.2	2.3
Spotted Seatrout / Fillet / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p* -dioxin	pg/g	2	1	50%	0.026	0.026	0.17	0.17	0.17
	1,2,3,7,8-Pentachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.026	0.036			
	1,2,3,4,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.024	0.029			
	1,2,3,6,7,8-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.033	0.080			
	1,2,3,7,8,9-Hexachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.025	0.030			
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p* -dioxin	pg/g	2	0	0%	0.070	0.080			
	Octachlorodibenzo-*p* -dioxin	pg/g	2	1	50%	0.58	0.58	0.70	0.70	0.70
	2,3,7,8-Tetrachlorodibenzofuran	pg/g	2	1	50%	0.27	0.27	1.1	1.1	1.1
	1,2,3,7,8-Pentachlorodibenzofuran	pg/g	2	1	50%	0.065	0.065	0.23	0.23	0.23
	2,3,4,7,8-Pentachlorodibenzofuran	pg/g	2	0	0%	0.026	0.026			
	1,2,3,4,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.034			
	1,2,3,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.030			
	1,2,3,7,8,9-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.029			
	2,3,4,6,7,8-Hexachlorodibenzofuran	pg/g	2	0	0%	0.028	0.029			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/g	2	0	0%	0.021	0.032			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/g	2	0	0%	0.037	0.055			
	Octachlorodibenzofuran	pg/g	2	0	0%	0.029	0.035			
Spotted Seatrout / Fillet / Semivolatile and Volatile Organic Compounds										
	1,1,1,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,1-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1,2,2-Tetrachloroethane	µg/kg	1	0	0%	10	10			
	1,1,2-Trichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,1-Dichloroethene	µg/kg	1	0	0%	10	10			
	1,1-Dichloropropene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichlorobenzene	µg/kg	1	0	0%	10	10			
	1,2,3-Trichloropropane	µg/kg	1	0	0%	10	10			
	1,2,4,5-Tetrachlorobenzene	mg/kg	1	0	0%	0.50	0.50			
	1,2,4-Trichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2,4-Trimethylbenzene	µg/kg	1	0	0%	10	10			
	1,2-Dibromo-3-chloropropane	µg/kg	1	0	0%	10	10			
	1,2-Dibromoethane	µg/kg	1	0	0%	10	10			
	1,2-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,2-Dichloroethane	µg/kg	1	0	0%	10	10			
	1,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,3,5-Trinitrobenzene	µg/kg	1	0	0%	10	10			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	1,3-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	1,3-Dichloropropane	µg/kg	1	0	0%	10	10			
	1,4-Dichlorobenzene	mg/kg	1	0	0%	0.010	0.010			
	2,2-Dichloropropane	µg/kg	1	0	0%	10	10			
	2,4,5-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4,6-Trichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dichlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dimethylphenol	mg/kg	1	0	0%	0.50	0.50			
	2,4-Dinitrophenol	mg/kg	1	0	0%	1.0	1.0			
	2,4-Dinitrotoluene	mg/kg	1	0	0%	1.0	1.0			
	2,6-Dinitrotoluene	mg/kg	1	0	0%	0.50	0.50			
	2-Butanone	µg/kg	1	0	0%	50	50			
	2-Chloronaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorophenol	mg/kg	1	0	0%	0.50	0.50			
	2-Chlorotoluene	µg/kg	1	0	0%	10	10			
	2-Hexanone	µg/kg	1	0	0%	10	10			
	2-Methylnaphthalene	mg/kg	1	0	0%	0.50	0.50			
	2-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	2-Nitroaniline	mg/kg	1	0	0%	0.50	0.50			
	2-Nitrophenol	mg/kg	1	0	0%	0.50	0.50			
	3,3'-Dichlorobenzidine	mg/kg	1	0	0%	2.0	2.0			
	3,4-Methylphenol	mg/kg	1	0	0%	0.50	0.50			
	3-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4,6-Dinitro-2-methylphenol	mg/kg	1	0	0%	1.0	1.0			
	4-Bromophenyl-phenylether	mg/kg	1	0	0%	0.50	0.50			
	4-Chloro-3-methylphenol	mg/kg	1	0	0%	0.50	0.50			
	4-Chloroaniline	mg/kg	1	0	0%	0.20	0.20			
	4-Chlorophenyl-phenyl ether	mg/kg	1	0	0%	0.50	0.50			
	4-Chlorotoluene	µg/kg	1	0	0%	10	10			
	4-Isopropyl toluene	µg/kg	1	0	0%	10	10			
	4-Methyl-2-pentanone	µg/kg	1	0	0%	10	10			
	4-Nitroaniline	mg/kg	1	0	0%	1.0	1.0			
	4-Nitrophenol	mg/kg	1	0	0%	2.0	2.0			
	Acenaphthene	mg/kg	1	0	0%	0.20	0.20			
	Acenaphthylene	mg/kg	1	0	0%	0.20	0.20			
	Acetone	µg/kg	1	0	0%	100	100			
	Acrylonitrile	µg/kg	1	0	0%	10	10			
	Aniline	mg/kg	1	0	0%	2.0	2.0			
	Anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzene	µg/kg	1	0	0%	10	10			
	Benzidine	mg/kg	1	0	0%	0	0			
	Benzo[a]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[a]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[b]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[g,h,i]perylene	mg/kg	1	0	0%	0.20	0.20			
	Benzo[k]fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Benzoic acid	mg/kg	1	0	0%	0.50	0.50			
	Benzyl alcohol	mg/kg	1	0	0%	0.50	0.50			
	Benzyl n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethoxy)methane	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-chloroethyl)ether	mg/kg	1	0	0%	1.0	1.0			
	Bis(2-chloroisopropyl) ether	mg/kg	1	0	0%	0.50	0.50			
	Bis(2-ethylhexyl) adipate	mg/kg	1	0	0%	0.50	0.50			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Bis(2-ethylhexyl)phthalate	mg/kg	1	0	0%	0.50	0.50			
	Bromobenzene	µg/kg	1	0	0%	10	10			
	Bromochloromethane	µg/kg	1	0	0%	10	10			
	Bromodichloromethane	µg/kg	1	0	0%	10	10			
	Bromoform	µg/kg	1	0	0%	10	10			
	Bromomethane	µg/kg	1	0	0%	25	25			
	Carbon disulfide	µg/kg	1	0	0%	25	25			
	Carbon Tetrachloride	µg/kg	1	0	0%	10	10			
	Chlorobenzene	µg/kg	1	0	0%	10	10			
	Chloroethane	µg/kg	1	0	0%	25	25			
	Chloroform	µg/kg	1	0	0%	10	10			
	Chloromethane	µg/kg	1	0	0%	25	25			
	Chrysene	mg/kg	1	0	0%	0.20	0.20			
	cis-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	cis-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Dibenzo[a,h]anthracene	mg/kg	1	0	0%	0.20	0.20			
	Dibenzofuran	mg/kg	1	0	0%	0.50	0.50			
	Dibromochloromethane	µg/kg	1	0	0%	10	10			
	Dibromomethane	µg/kg	1	0	0%	10	10			
	Dichlorodifluoromethane	µg/kg	1	0	0%	25	25			
	Diethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Dimethyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-butyl phthalate	mg/kg	1	0	0%	0.50	0.50			
	Di-n-octylphthalate	mg/kg	1	0	0%	0.50	0.50			
	Diphenylhydrazine	mg/kg	1	0	0%	0.50	0.50			
	Ethyl methacrylate	µg/kg	1	0	0%	10	10			
	Ethylbenzene	µg/kg	1	0	0%	10	10			
	Fluoranthene	mg/kg	1	0	0%	0.20	0.20			
	Fluorene	mg/kg	1	0	0%	0.20	0.20			
	Hexachlorobenzene	mg/kg	2	2	100%			0.0022	0.0027	0.0031
	Hexachlorobutadiene	mg/kg	1	0	0%	0.025	0.025			
	Hexachlorocyclopentadiene	mg/kg	1	0	0%	2.0	2.0			
	Hexachloroethane	mg/kg	1	0	0%	0.50	0.50			
	Hexachlorophene	mg/kg	1	0	0%	0	0			
	Indeno[1,2,3-cd]pyrene	mg/kg	1	0	0%	0.20	0.20			
	Iodomethane	µg/kg	1	0	0%	25	25			
	Isophorone	mg/kg	1	0	0%	0.50	0.50			
	Isopropylbenzene	µg/kg	1	0	0%	10	10			
	m,p-Xylene	µg/kg	1	0	0%	20	20			
	Methyl methacrylate	µg/kg	1	0	0%	10	10			
	Methyl tert-butyl ether	µg/kg	1	0	0%	10	10			
	Methylene Chloride	µg/kg	1	0	0%	25	25			
	Naphthalene	mg/kg	1	0	0%	0.010	0.010			
	n-Butylbenzene	µg/kg	1	0	0%	10	10			
	Nitrobenzene	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso diethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-nitroso-dibutylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodimethylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodi-n-propylamine	mg/kg	1	0	0%	0.50	0.50			
	N-Nitrosodiphenylamine	mg/kg	1	0	0%	0.50	0.50			
	n-Propylbenzene	µg/kg	1	0	0%	10	10			
	o-Xylene	µg/kg	1	0	0%	10	10			
	Pentachlorophenol	mg/kg	1	0	0%	1.0	1.0			

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Phenanthrene	mg/kg	1	0	0%	0.20	0.20			
	Phenol	mg/kg	1	0	0%	0.50	0.50			
	Pyrene	mg/kg	1	0	0%	0.20	0.20			
	Pyridine	mg/kg	1	0	0%	0.50	0.50			
	sec-Butylbenzene	µg/kg	1	0	0%	10	10			
	Styrene	µg/kg	1	0	0%	10	10			
	tert-Butylbenzene	µg/kg	1	0	0%	10	10			
	Tetrachloroethene	µg/kg	1	0	0%	10	10			
	Tetrahydrofuran	µg/kg	1	0	0%	25	25			
	Toluene	µg/kg	1	0	0%	10	10			
	trans-1,2-Dichloroethene	µg/kg	1	0	0%	10	10			
	trans-1,3-Dichloropropene	µg/kg	1	0	0%	50	50			
	Trichloroethene	µg/kg	1	0	0%	10	10			
	Trichlorofluoromethane	µg/kg	1	0	0%	25	25			
	Vinyl Chloride	µg/kg	1	0	0%	25	25			
Spotted Seatrout / Fillet / Pesticides										
	4,4'-DDD	mg/kg	2	0	0%	0.0050	0.0050			
	4,4'-DDE	mg/kg	2	1	50%	0.0025	0.0025	0.0057	0.0057	0.0057
	4,4'-DDT	mg/kg	2	0	0%	0.0050	0.0050			
	Aldrin	mg/kg	2	0	0%	0.0010	0.0010			
	alpha-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	beta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Chlordane	µg/kg	2	2	100%			48	48	48
	Chlorpyrifos	µg/kg	2	0	0%	5.0	5.0			
	delta-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Diazinon	µg/kg	2	0	0%	5.0	5.0			
	Dieldrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endosulfan I	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan II	mg/kg	2	0	0%	0.0050	0.0050			
	Endosulfan sulfate	mg/kg	2	0	0%	0.0050	0.0050			
	Endrin	mg/kg	2	0	0%	0.0030	0.0030			
	Endrin aldehyde	mg/kg	1	0	0%	0	0			
	Endrin ketone	mg/kg	1	0	0%	0.50	0.50			
	gamma-Benzenehexachloride	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor	mg/kg	2	0	0%	0.0010	0.0010			
	Heptachlor epoxide	mg/kg	2	2	100%			0.0040	0.0044	0.0048
	Malathion	µg/kg	2	0	0%	10	10			
	Methoxychlor	µg/kg	2	0	0%	15	15			
	Methyl parathion	µg/kg	2	0	0%	5.0	5.0			
	Mirex	µg/kg	2	0	0%	4.0	4.0			
	Parathion	µg/kg	2	0	0%	5.0	5.0			
	Toxaphene	µg/kg	2	0	0%	50	50			
Spotted Seatrout / Fillet / Herbicides										
	Alachlor	µg/kg	2	0	0%	4.0	4.0			
	Dimethyl tetrachloroterephthalate	µg/kg	2	0	0%	1.5	1.5			
Spotted Seatrout / Fillet / Polychlorinated Biphenyls										
	Aroclor 1016	µg/kg	2	0	0%	20	20			
	Aroclor 1221	µg/kg	2	0	0%	20	20			
	Aroclor 1232	µg/kg	2	0	0%	20	20			
	Aroclor 1242	µg/kg	2	0	0%	20	20			
	Aroclor 1248	µg/kg	2	0	0%	20	20			
	Aroclor 1254	µg/kg	2	0	0%	20	20			
	Aroclor 1260	µg/kg	2	2	100%			63	68	72

Table 2-12
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum

Notes:
All concentrations are on a wet weight basis.

Table 2-13
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
Blue Catfish / Edible / Physical and Chemical										
	Lipid	percent	4	3	75%	0.050	0.050	0.40	0.60	0.70
Blue Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			0.62	2.0	3.5
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	4	2	50%	0.15	0.27	0.17	0.19	0.21
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	1	25%	0.050	0.15	0.17	0.17	0.17
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			0.21	0.43	0.64
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	1	25%	0.065	0.16	0.20	0.20	0.20
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			0.23	0.90	1.3
	Octachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			1.6	4.3	6.3
	Tetrachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	4	100%			0.62	2.0	3.5
	Pentachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	3	75%	0.27	0.27	0.17	0.36	0.69
	Hexachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	4	100%			0.21	0.51	0.94
	Heptachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	4	100%			0.23	1.2	1.8
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	2	50%	0.060	0.22	0.27	0.35	0.42
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	1	25%	0.044	0.16	0.11	0.11	0.11
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	1	25%	0.11	0.24	0.27	0.27	0.27
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.070	0.19	0.067	0.080	0.092
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.075	0.16			
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.032	0.075	0.71	0.71	0.71
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	2	50%	0.075	0.24	0.083	0.092	0.10
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	1	25%	0.12	0.47	0.28	0.28	0.28
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.060	0.55			
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.82	1.6	2.8
	Tetrachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.060	22	0.27	0.35	0.42
	Pentachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.28	0.28	0.61	1.3	2.0
	Hexachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.21	0.89	2.2
	Heptachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.55	0.55	0.29	0.55	1.0
Blue Catfish / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	1	100%			0.48	0.48	0.48
	Total PCBs	mg/kg	1	1	100%			0.48	0.48	0.48
Blue Crab / Edible / Physical and Chemical										
	Lipid	percent	4	4	100%			0.70	0.95	1.2
Blue Crab / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	4	3	75%	0.14	0.14	0.87	2.8	6.2
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	4	3	75%	0.23	0.23	0.16	0.17	0.18
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	2	50%	0.060	0.085	0.15	0.17	0.18
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	3	75%	0.11	0.11	0.30	0.40	0.60
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	4	2	50%	0.095	0.11	0.24	0.25	0.26
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			0.29	0.78	1.1
	Octachlorodibenzo-*p*-dioxin	ng/kg	4	4	100%			1.7	4.7	9.5
	Tetrachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	3	75%	0.14	0.14	1.1	3.5	6.7
	Pentachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	4	100%			0.16	0.65	0.93
	Hexachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	3	75%	0.095	0.095	0.86	2.7	3.8

Table 2-13
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits Minimum	Detection Limits Maximum	Detected Data Minimum	Detected Data Mean	Detected Data Maximum
	Heptachlorodibenzo-*p*-dioxin (Total)	ng/kg	4	4	100%			0.56	1.8	2.7
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	4	3	75%	0.11	0.11	1.6	6.4	14
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	4	2	50%	0.065	0.11	0.16	0.21	0.26
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	4	3	75%	0.11	0.11	0.23	0.30	0.40
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.055	0.095	0.19	0.19	0.19
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	4	1	25%	0.049	0.11	0.15	0.15	0.15
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.046	0.10			
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	4	0	0%	0.048	0.11			
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	4	0	0%	0.10	0.19			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	4	1	25%	0.055	0.20	0.28	0.28	0.28
	Octachlorodibenzofuran	ng/kg	4	4	100%			0.38	0.83	2.1
	Tetrachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.34	0.34	2.7	10	20
	Pentachlorodibenzofuran (Total)	ng/kg	4	3	75%	0.55	0.55	0.79	2.1	3.2
	Hexachlorodibenzofuran (Total)	ng/kg	4	4	100%			0.35	1.7	5.2
	Heptachlorodibenzofuran (Total)	ng/kg	4	2	50%	0.11	0.19	0.26	0.53	0.79
Blue Crab / Edible / Polychlorinated Biphenyls										
	Aroclor 1016	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1221	mg/kg	1	0	0%	0.0075	0.0075			
	Aroclor 1232	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1242	mg/kg	1	0	0%	0.019	0.019			
	Aroclor 1248	mg/kg	1	0	0%	0.011	0.011			
	Aroclor 1254	mg/kg	1	0	0%	0.030	0.030			
	Aroclor 1260	mg/kg	1	0	0%	0.016	0.016			
	Total PCBs	mg/kg	1	0	0%	0.030	0.030			
Hardhead Catfish / Edible / Physical and Chemical										
	Lipid	percent	1	1	100%			4.0	4.0	4.0
Hardhead Catfish / Edible / Dioxins and Furans										
	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			14	14	14
	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			0.50	0.50	0.50
	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			0.45	0.45	0.45
	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			1.3	1.3	1.3
	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			0.43	0.43	0.43
	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			1.7	1.7	1.7
	Octachlorodibenzo-*p*-dioxin	ng/kg	1	1	100%			3.8	3.8	3.8
	Tetrachlorodibenzo-*p*-dioxin (Total)	ng/kg	1	1	100%			14	14	14
	Pentachlorodibenzo-*p*-dioxin (Total)	ng/kg	1	1	100%			0.50	0.50	0.50
	Hexachlorodibenzo-*p*-dioxin (Total)	ng/kg	1	1	100%			2.2	2.2	2.2
	Heptachlorodibenzo-*p*-dioxin (Total)	ng/kg	1	1	100%			1.7	1.7	1.7
	2,3,7,8-Tetrachlorodibenzofuran	ng/kg	1	1	100%			0.76	0.76	0.76
	1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	1	1	100%			0.19	0.19	0.19
	2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	1	1	100%			0.82	0.82	0.82
	1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	1	0	0%	0.18	0.18			
	1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	1	1	100%			0.18	0.18	0.18
	1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	1	0	0%	0.060	0.060			
	2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	1	1	100%			0.22	0.22	0.22
	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	1	0	0%	0.16	0.16			
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	1	0	0%	0.085	0.085			
	Octachlorodibenzofuran	ng/kg	1	0	0%	0.22	0.22			
	Tetrachlorodibenzofuran (Total)	ng/kg	1	1	100%			0.76	0.76	0.76
	Pentachlorodibenzofuran (Total)	ng/kg	1	1	100%			1.2	1.2	1.2

Table 2-13
Detection Frequencies and Summary Statistics for Analytes Measured in Tissue Samples Collected from Upstream of the Site in 2002-2004

Species / Tissue / Chemical Group	Analyte	Units	Number of Samples	Number of Detected Measurements	Detection Frequency	Detection Limits		Detected Data		
						Minimum	Maximum	Minimum	Mean	Maximum
	Hexachlorodibenzofuran (Total)	ng/kg	1	1	100%			0.56	0.56	0.56
	Heptachlorodibenzofuran (Total)	ng/kg	1	0	0%	0.21	0.21			

Table 2-14
Chronological Summary of TDSHS Fish Consumption Advisories Relevant to the Site

Advisory Activity	Date	Description of Activity
Advisory ADV-3 issued (TDH 1990)	9/19/1990	ADV-3 covered the Houston Ship Channel and all contiguous waters, and Upper Galveston Bay north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. ADV-3 was based on health concerns regarding dioxin in catfish and blue crabs.
Advisory ADV-3 re-evaluated based on new monitoring data	--	Re-evaluated ADV-3 based on results from the 1994 Near Coastal Water Grant study by TDSHS. Based on re-evaluation, the TDSHS continued ADV-3, unchanged from the original 1990 consumption advisory issued for these areas.
Advisory ADV-3 re-evaluated based on new monitoring data	--	Re-evaluated ADV-3 based on new results from 24 seafood samples collected by TDSHS in April 1996 from Houston Ship Channel and Upper Galveston Bay. Based on re-evaluation, the TDSHS continued ADV-3, unchanged from the original 1990 consumption advisory issued for these areas.
Report Issued: *Health Consultation For Consumption of Seafood From Houston Ship Channel and Upper Galveston Bay* (TDH 1997)	5/12/1997	Summarized re-evaluation of ADV-3 based on 1996 TDSHS monitoring data. Major recommendations included: 1) The Houston Ship Channel advisory of 1990 should continue to limit consumption of catfish and crabs. 2) If the restricted status of oysters in the Houston Ship Channel advisory area should change in the future, inclusion of oysters in the consumption advisory should be considered due to dioxin contamination of these oysters. 3) Other species of fish should remain excluded from the consumption advisory since they do not pose a significant health risk.
Report Issued: *Health Consultation Houston Ship Channel and Tabbs Bay. Harris County, Texas* (TDH 2001a)	8/1/2001	Summarized re-evaluation of ADV-3 based on 1999 TDSHS monitoring data. Major recommendations relevant to Site waters included: 1) That TDSHS continue the existing advisory (ADV-3) on consumption of blue crabs and catfish from the Houston Ship Channel and contiguous waters, including Tabbs Bay. 2) That TDSHS issue a second advisory (ADV-20) for the Houston Ship Channel and the San Jacinto River to include all species of finfish due to the presence of pesticides and PCBs in concentrations exceeding health-based assessment comparison values (HAC values).
Advisory ADV-20 issued (TDH 2001b)	10/9/2001	ADV-20 issued based on samples of fish taken from the Houston Ship Channel upstream of the Lynchburg Ferry crossing and from the San Jacinto River downstream of the U.S. Highway 90 bridge, which indicated the presence of organochlorine pesticides and polychlorinated biphenyls at concentrations that may pose a threat to human health if consumed. ADV-20 expanded advisory coverage of same waters covered by ADV-3.
Report Issued: *Characterization of Potential Health Risks Associated with Consumption of Fish or Blue Crabs from the Houston Ship Channel, the San Jacinto River (Tidal Portions), Tabbs Bay, and Upper Galveston Bay. Harris and Chambers Counties, Texas* (TDSHS 2005a)	1/10/2005	Summarized re-evaluation of ADV-3 based on 2004 TDSHS monitoring data, collected in collaboration with the TCEQ. Major recommendations relevant to Site waters included: 1) That TDSHS continue the existing advisory (ADV-3) on consumption of blue crabs and catfish from the Houston Ship Channel and contiguous waters, including Upper Galveston Bay and Tabbs Bay. 2) TDSHS continue the advisory (ADV-20) for the Houston Ship Channel and the San Jacinto River that includes all species of fish due to the presence of elevated concentrations of pesticides and PCBs. 3) That TDSHS modify consumption advice for the Houston Ship Channel – including the tidal portion of the San Jacinto River, Tabbs Bay, and all contiguous waters – and Upper Galveston Bay to inform people that health risks may be associated with consumption of spotted seatrout containing polychlorinated biphenyls, chlorinated pesticides, or dioxin (ADV-28).
Advisory ADV-28 issued (TDSHS 2005b)	1/27/2005	Issued based on monitoring data for spotted seatrout collected from Upper Galveston Bay, Tabbs Bay, and the tidal portion of the San Jacinto River, which indicated the presence of PCBs at concentrations that may pose a threat to human health if consumed.

Table 3-1
Summary of Data Quality and Usability Assessment Checks

	Checks to be Performed	Stage 1	Stage 2A	Stage 2B	Stage 3	Stage 4
1	Analytical laboratory identified, sample documentation (COCs) included	X	X	X	X	X
2	Requested analytical methods performed, analysis dates present	X	X	X	X	X
3	Requested target analyte results reported with lab data qualifiers and qualifier definitions	X	X	X	X	X
4	Requested target analyte result units reported	X	X	X	X	X
5	Requested RLs met	X	X	X	X	X
6	Sampling dates & times, date & time of lab receipt, and sample conditions documented	X	X	X	X	X
7	Rad-chem ONLY - Sample-specific critical values and minimum detectable values reported	X	X	X	X	X
8	Rad-chem ONLY - Chemical yield and reference date & time reported	X	X	X	X	X
9	Sample results evaluated using Stage 1 criteria	X	X	X	X	X
10	Requested methods performed (handling, prep, cleanup, and analytical)		X	X	X	X
11	Dates for preparation, cleanup, & other sample handling steps present		X	X	X	X
12	Sample-related QC data and QC acceptance criteria present		X	X	X	X
13	Requested spike analytes/compounds added as appropriate (e.g. surrogates, LCS, etc.)		X	X	X	X
14	Holding times met		X	X	X	X
15	QC sample frequency met (e.g., one LCS per 20 samples in a prep batch)		X	X	X	X
16	Sample results evaluated using Stage 2A criteria		X	X	X	X
17	Initial calibration data (e.g., ICAL, ICV, ICBs) present			X	X	X
18	Appropriate number and concentration of ICAL standards present			X	X	X
19	Continuing calibration data (e.g., CCV, CCBs) present			X	X	X
20	Samples bracketed by CCV/CCB, as needed			X	X	X
21	Instrument performance checks present (e.g. tune, DDT breakdown, etc)			X	X	X
22	Appropriate frequency of instrument QC samples			X	X	X
23	Sample results evaluated using Stage 2B criteria			X	X	X
24	Instrument response data (e.g., GC peak areas, ICP corrected intensities), MS/MSDs, LCS, MBs, calibration data and instrument QC checks (e.g. tunes, DDT/Endrin breakdowns, interelement correction factors, and Florisil cartridge checks) reported				X	X
25	Reported target analyte instrument responses associated with appropriate internal standard analyte(s)				X	X
26	Appropriate ICAL curve used				X	X
27	Compare instrument response to minimum response requirements for each analyte				X	X
28	Recalculation of each CCV (and CCB) response from peak data, as appropriate				X	X
29	Compliance check of recalculated CCV (and CCB)				X	X
30	Recalculation of % ratios for each tune from the instrument response, as appropriate				X	X
31	Compliance check of recaculated % ratio				X	X
32	Recalculation of instrument performance checks (e.g., DDT/Endrin breakdown for pesticide analysis, instrument blanks, interference checks)				X	X
33	Recalculation and compliance check of retention time windows				X	X
34	Recalculation of reported target analyte results				X	X
35	Recalculation of each (or selected) reported spike recovery				X	X
36	Sample results evaluated using Stage 3 criteria				X	X
37	All required instrument outputs for evaluating sample & instrument performance are present					X
38	Sample results evaluated by checking against instrument output					X
39	Each instrument's output evaluated for confirmation of non-detected or TIC analytes					X

Notes:

CCB = continuing calibration blank
CCV = continuing calibration verification
COC = chain-of-custody
ICAL = initial calibration standards
ICB = initial calibration blank
ICV = initial calibration verification
LCS = laboratory control standard
MB = method blank
MS/MSD = matrix spike/matrix spike duplicate
QC = quality control
RL = reporting limit
TIC = tentatively identified compound

Table 3-2
Data Quality Assessment Summary - Historical Data

Data Study Reference[a]	Matrix	Data Quality Assessment Category
ENSR and EHA 1995	Sediment	Cat 2
ENSR and EHA 1995	Surface Water[b]	Cat 2
ENSR and EHA 1995	Tissue	Cat 2
Orion 2009	Sediment	Cat 2
TCEQ and USEPA 2006	Sediment	Cat 1
Texas Department of State Health Services	Tissue	Cat 2
University of Houston and Parsons 2006	Sediment	Cat 2
University of Houston and Parsons 2006	Air	Cat 2
University of Houston and Parsons 2006	Tissue	Cat 2
University of Houston and Parsons 2006	Surface Water	Cat 2
URS 2010	Sediment	Cat 1
URS 2010	Surface Water	Cat 1
Weston 2006	Sediment	Cat 2

Notes:

Cat 1 = Data are of known quality and are considered acceptable for use in decision making

Cat 2 = Data are of unknown quality, suspect quality, or insufficient information is available to assess data quality for decision making purposes

[a]This data represents the data available at the time this Work Plan was being produced. Any additional data incorporated into the project database will undergo the same data quality assessment process.

[b]While surface water data quality from ENSR and EHA 1995 was assessed, these data were not included in the data used to evaluate the chemical setting for the Site (Table 2-4), because this surface water data set was not considered representative of baseline conditions.

Table 4-1
Toxicity Equivalency Factors for Dioxins and Furans

Compound	Mammalian TEFs[a]	Avian TEFs[b]	Fish TEFs[b]
Chlorinated Dibenzo-*p* -Dioxins			
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.05	0.5
1,2,3,6,7,8-HxCDD	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01
1,2,3,4,6,7,8-HpCDD	0.01	<0.001	0.001
OCDD	0.0003	0.0001	<0.0001
Chlorinated Dibenzofurans			
2,3,7,8-TCDF	0.1	1	0.05
1,2,3,7,8-PeCDF	0.03	0.1	0.05
2,3,4,7,8-PeCDF	0.3	1	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
OCDF	0.0003	0.0001	<0.0001

Notes:
TEF = toxicity equivalency factor

Table 6-1
Summary of Ecological Receptor Surrogates

Receptor Group	Receptor Surrogate	Feeding Guild	Potentially Present	Representative of One or More Feeding Guilds	High Site Fidelity/Residential	Sensitive or Potentially Highly Exposed	Life History Information Is Readily Available	Additional Considerations
Benthic macroinvertebrates								
	Molluscs	Filter feeders	X	X	X	X [a]	X	Close association with sediment
Fish								
	Gulf killifish	Omnivore	X	X	X		X	Common prey for other fish and bird species
	Black drum	Benthic invertivore	X	X	X		X	Popular sport fish; limited range, limited interbay movement
	Southern flounder	Benthic piscivore	X	X	X [b]	X	X	Supports commercial and recreational fisheries
Reptiles								
	Alligator snapping turtle	Omnivore	X	X	X	X	X [c]	Sensitive species (state threatened)
Birds								
	Neotropic cormorant	Piscivore (diving)	X	X			X	
	Great blue heron	Piscivore (wading)	X	X			X	
	Spotted sandpiper	Invertivore (probing)	X	X		X	X	As a sediment-probing invertivore, expected to be closely associated with sediment exposure pathway
	Killdeer	Invertivore (terrestrial)	X	X	X		X	Feeds on invertebrate fauna closely associated with soils
Mammals								
	Marsh Rice Rat	Omnivore	X	X	X		X	Semi-aquatic, diet consists of aquatic and emergent plants, and invertebrates
	Raccoon	Omnivore	X	X			X	Representative of both aquatic and terrestrial omnivorous feeding guilds

Notes

a - Sensitive reproductive endpoint, see Appendix B, Attachment B2.

b - Site fidelity is probably high except in winter, when this species moves into more saline waters to spawn.

c - Life history information is readily available for another turtle in the snapping turtle family, the common snapping turtle (*Chelydra serpentina*).

Table 6-2
Summary of Receptor Surrogates, Assessment Endpoints, and Risk Questions for the BERA

Receptor Class	Assessment Endpoint	Risk Questions
Benthic macroinvertebrates	Functional benthic macroinvertebrate community	Are the concentrations of chemicals of potential concern (COPCs) in whole sediment from benthic habitats of the Site greater than threshold concentrations relating to the survival, growth, or reproduction of benthic invertebrates, or the productivity or viability of invertebrate populations or communities?
Bivalve molluscs	Stable or increasing populations of bivalves within the Site	Are concentrations of organic primary COPCs in tissue of field collected clams equal to or greater than concentrations considered threshold levels of reproductive effects in molluscs?
Fish	Stable or increasing populations of fish in the following feeding guilds:	Are the concentrations of COPCs in waters of the Site greater than threshold concentrations relating to the survival, growth, or reproduction of fish?
	- Benthic omnivore - Benthic invertivore - Benthic piscivore	Are the concentrations of inorganic COPCs (metals) in the diet of fish greater than threshold effect levels for survival, growth, or reproduction of fish?
		Are concentrations of organic COPCs in fish tissue from the Site greater than the concentrations of COPCs associated with effects on the survival, growth or reproduction of fish?
Reptiles	Stable or increasing populations of omnivorous reptiles	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth and reproduction of reptiles?
Birds	Stable or increasing populations of birds (that may be exposed to COPCs from the Site) in the following feeding guilds:	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth, and reproduction of birds? Is the estimated concentration of dioxins and furans, expressed as TEQs, in bird eggs greater than threshold concentrations for reproductive effects in birds?
	- Invertivore (aquatic and terrestrial)	
	- Omnivorous wading bird	
	- Piscivorous diving bird	
Mammals	Stable or increasing populations of omnivorous mammals	Is the total daily ingested dose (mg/kg bw-day) of COPCs greater than doses known to cause effects on the survival, growth and reproduction of mammals?

FIGURES

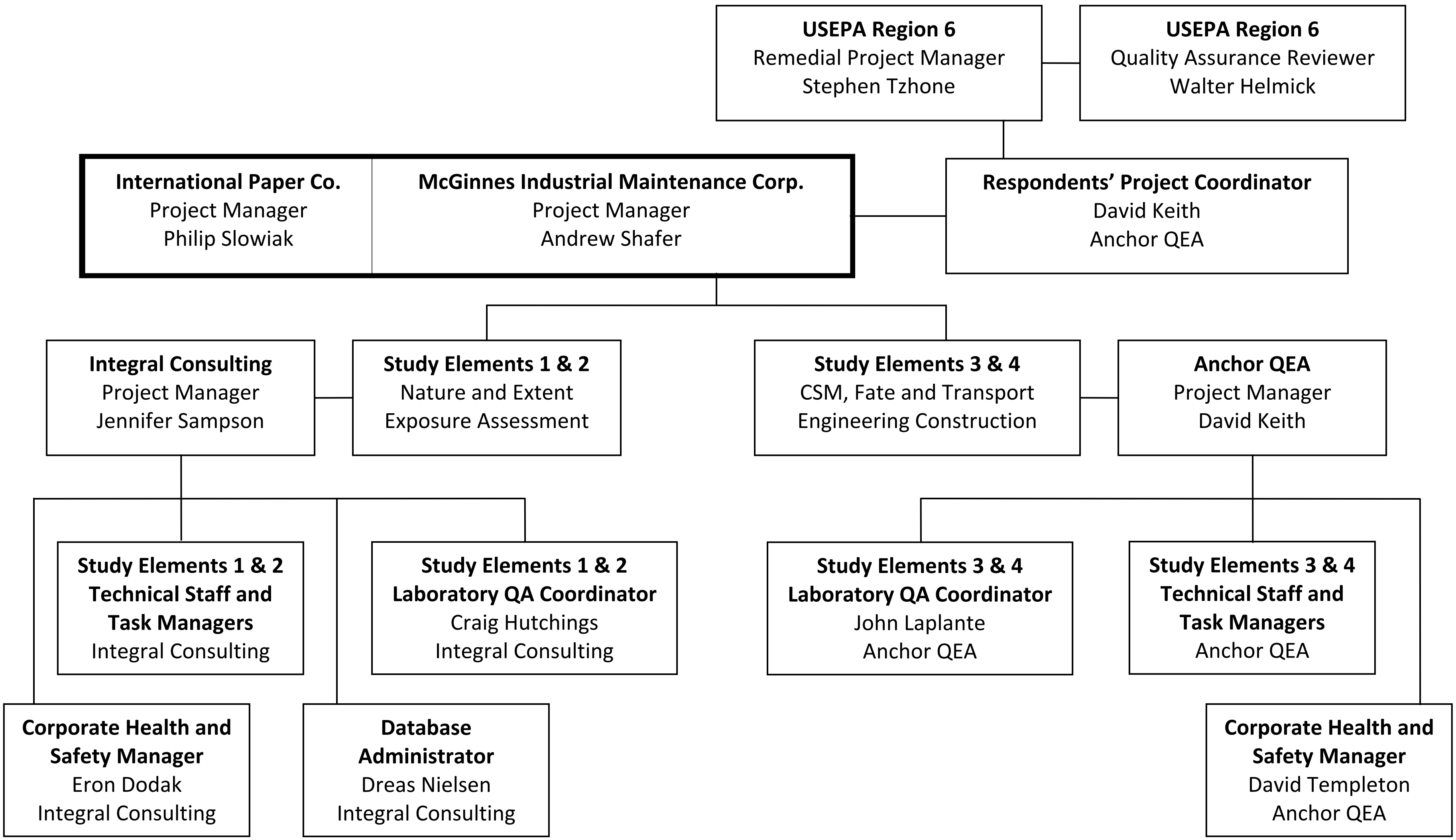
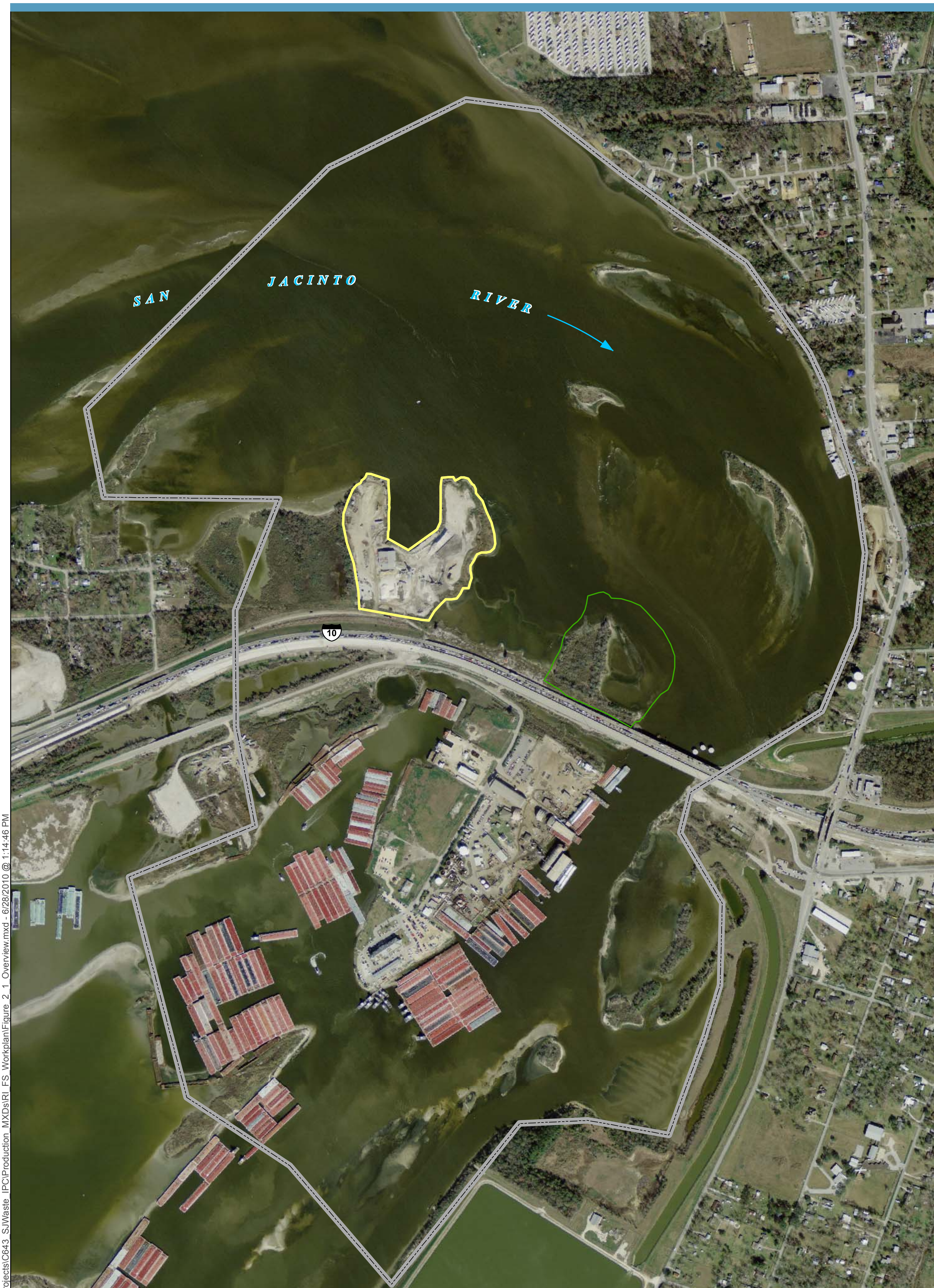


Figure 1-1
Project Organization Chart
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT



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Preliminary Site Perimeter
Property West of the Impoundments
Original (1966) Perimeter of the Impoundments

0 800
Scale in Feet

FEATURE SOURCES:
Aerial Imagery: 0.5-meter January 2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIS

Figure 2-1
Overview of Current Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

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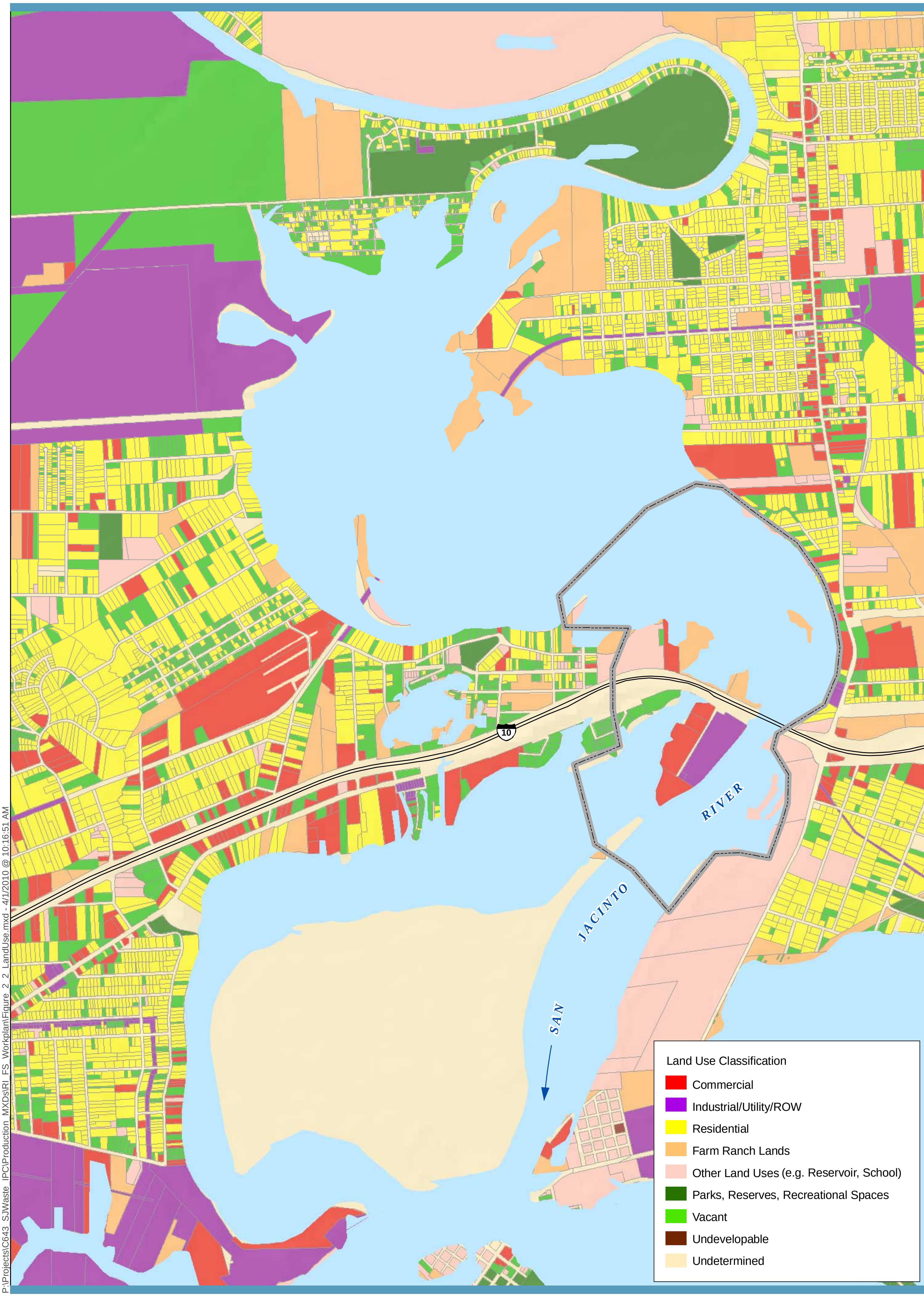
DO NOT QUOTE OR CITE



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Preliminary Site Perimeter
Tax Parcel Boundary

0 0.5
Scale in Miles

FEATURE SOURCES:
Zoning: Houston-Galveston Area Council
Parcel Boundaries: Harris County Appraisal District

Figure 2-2
Land Use in the Vicinity of the Site
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

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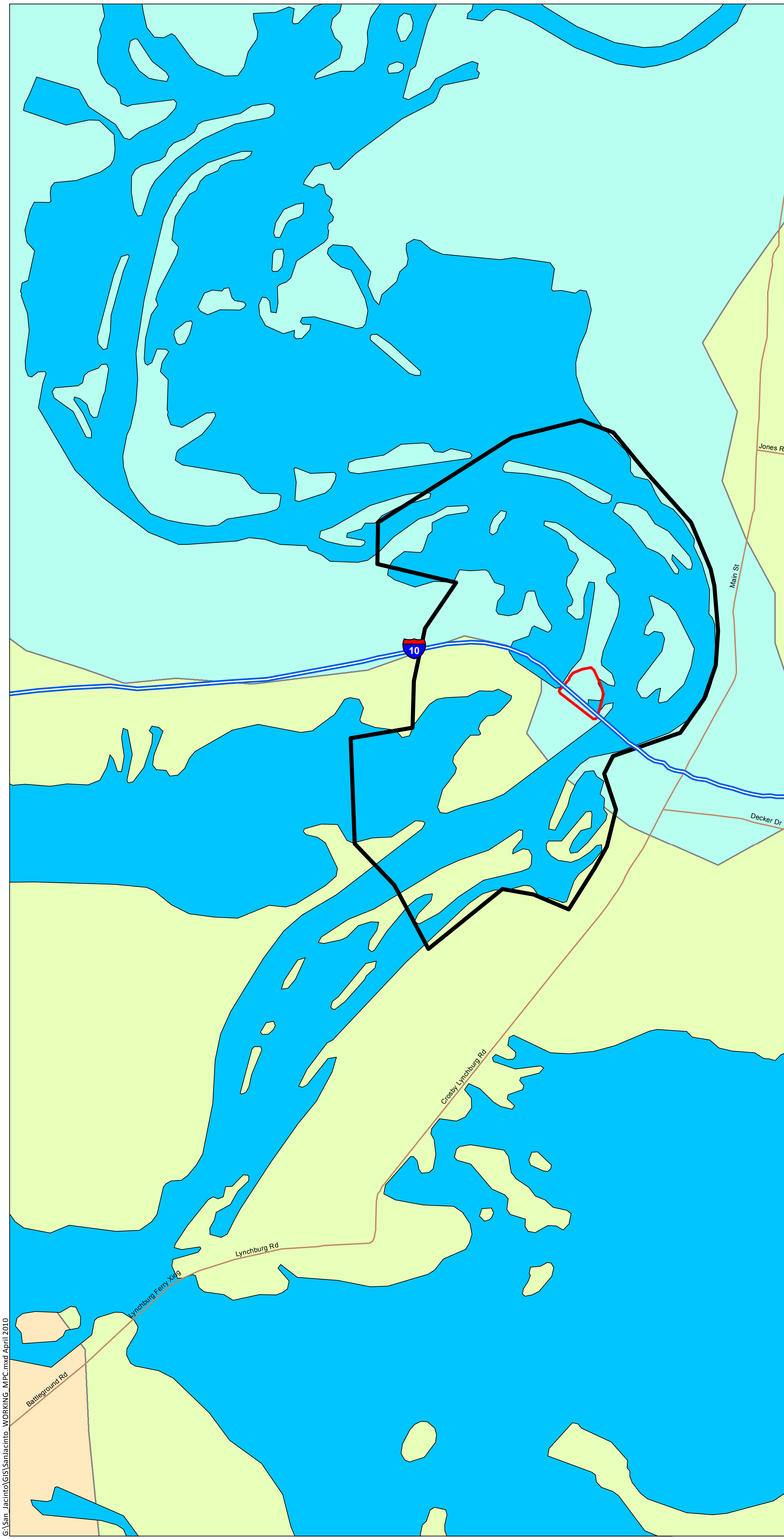

NOTES:

Legend

- Preliminary Site Perimeter
- Original (1966) Perimeter of the Impoundments
- San Jacinto River

San Jacinto Watershed Sub-basins

- HSC
- Houston Ship Ch./San Jacinto River
- San Jacinto River Tidal

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Miles
0 0.25 0.5

Figure 2-3

San Jacinto River Watersheds and Sub-basins

SJRWP RI/FS Work Plan

SJRWP Superfund/ MIMC and IPC

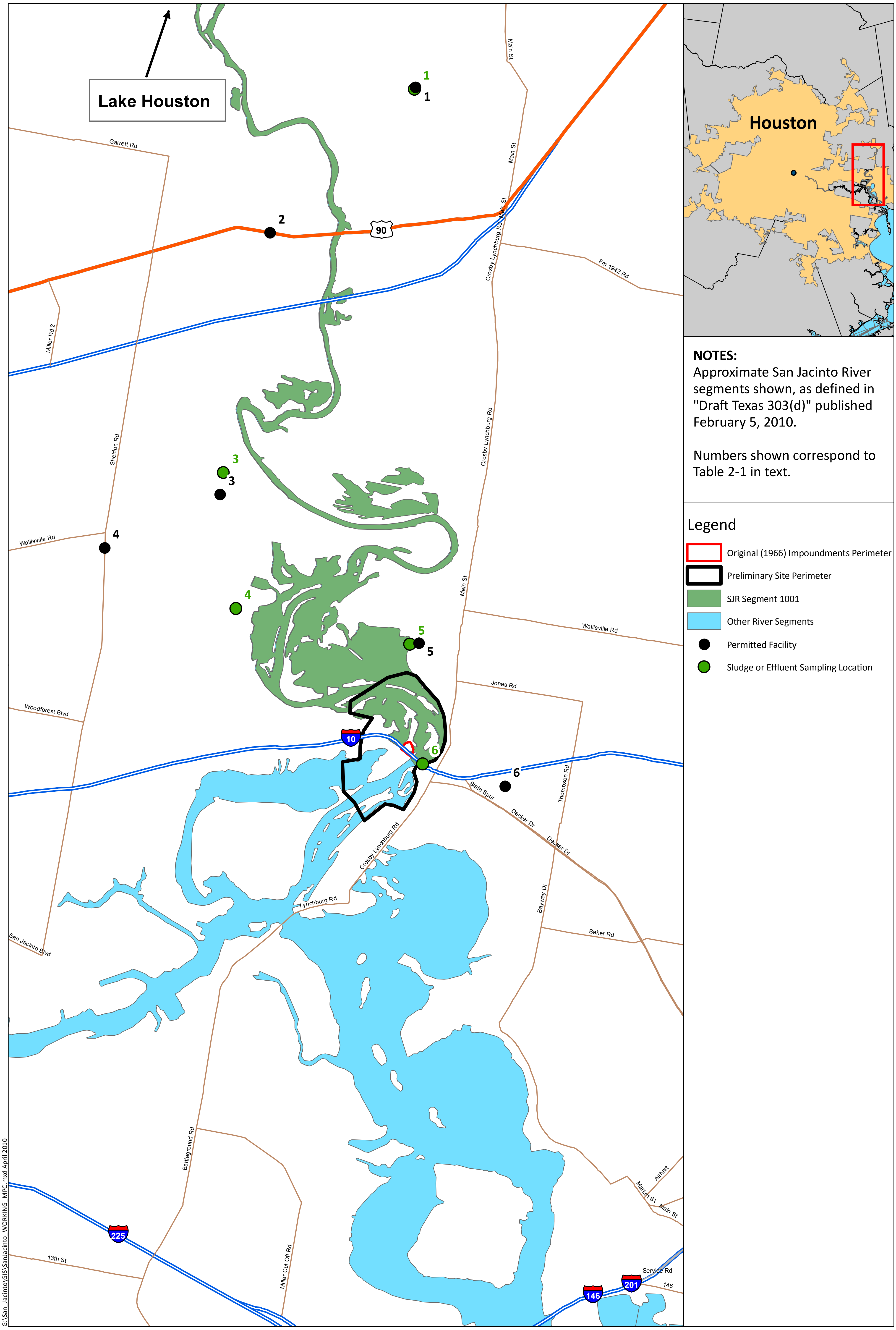

Figure 2-4

Permitted Dischargers and TMDL Sampling Locations

SJRWP RI/FS Work Plan

SJRWP Superfund/ MIMC and IPC

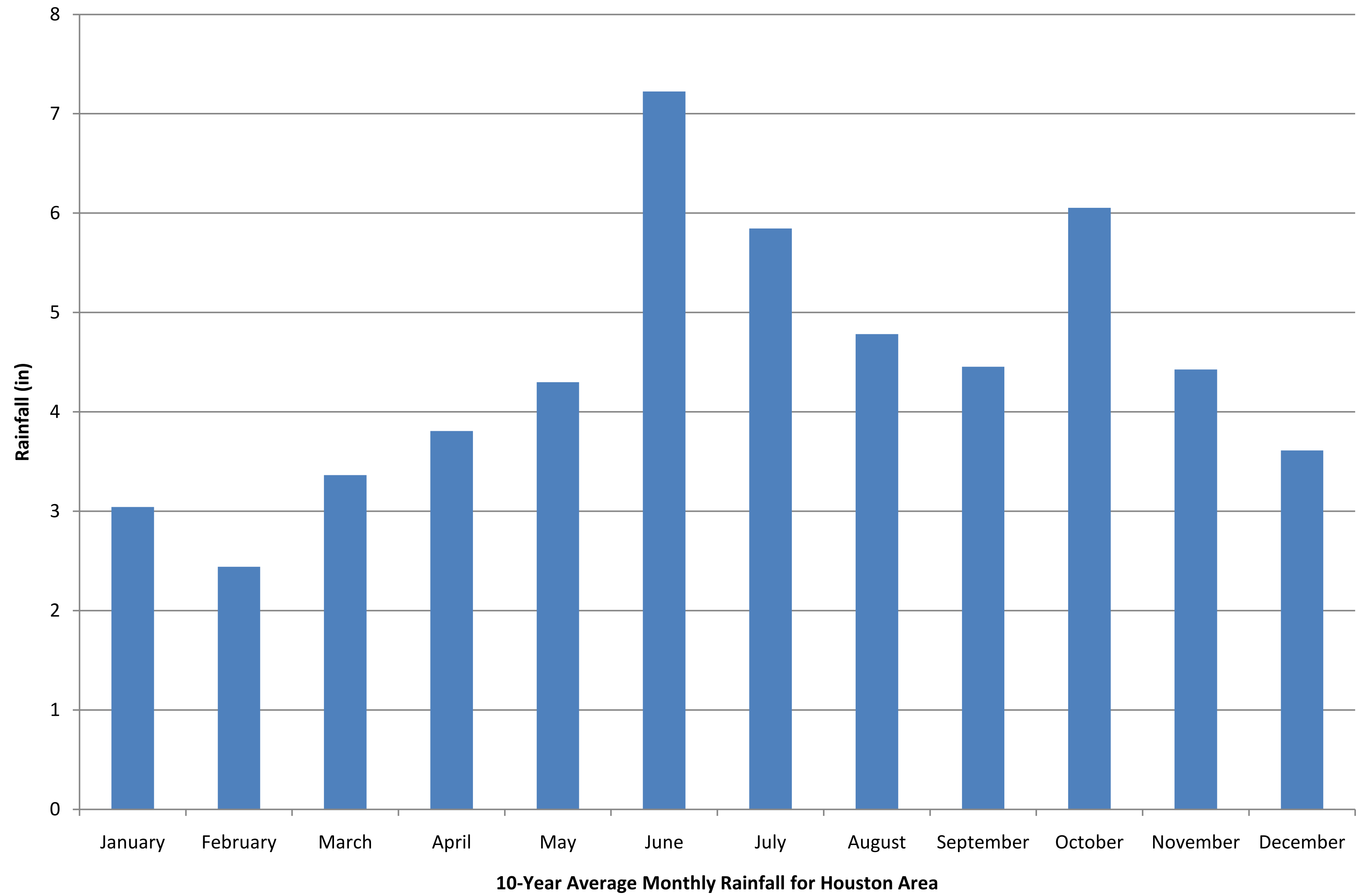

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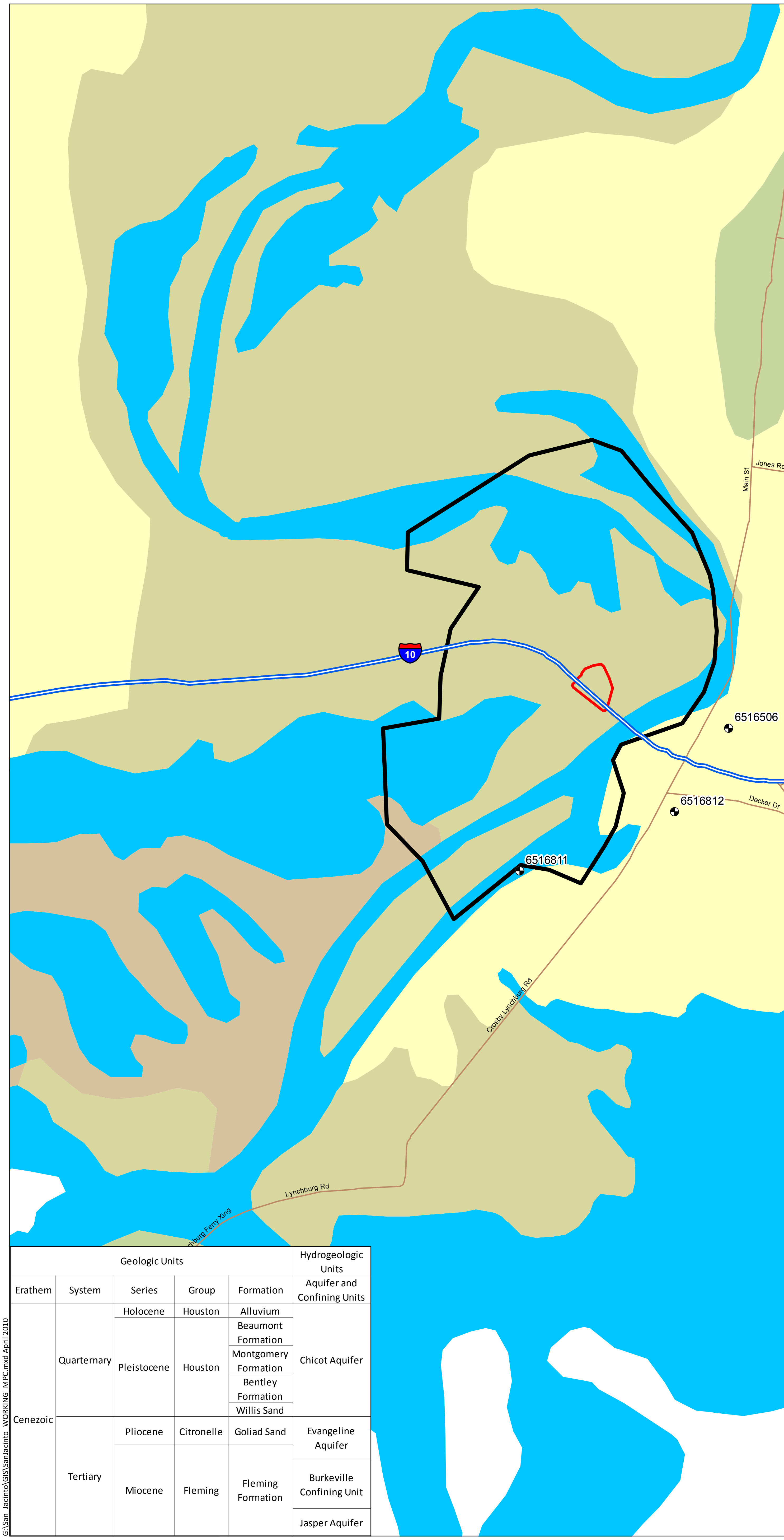
Figure 2-5
10-Year Average Monthly Rainfall for Houston Area
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



Geologic Units					Hydrogeologic Units
Erathem	System	Series	Group	Formation	Aquifer and Confining Units
Cenezoic	Quarternary	Holocene	Houston	Alluvium	Chicot Aquifer
		Pleistocene	Houston	Beaumont Formation	
				Montgomery Formation	
				Bentley Formation	
				Willis Sand	
	Tertiary	Pliocene	Citronelle	Goliad Sand	Evangeline Aquifer
		Miocene	Fleming	Fleming Formation	Burkeville Confining Unit
					Jasper Aquifer

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NOTES:

Legend

- Original (1966) Impoundments Perimeter
- Preliminary Site Perimeter
- Holocene Fluvial Sands
- Holocene Alluvium
- Pleistocene Beaumont Formation
- Pleistocene Beaumont Formation
- Water (approximate)
- Groundwater Wells

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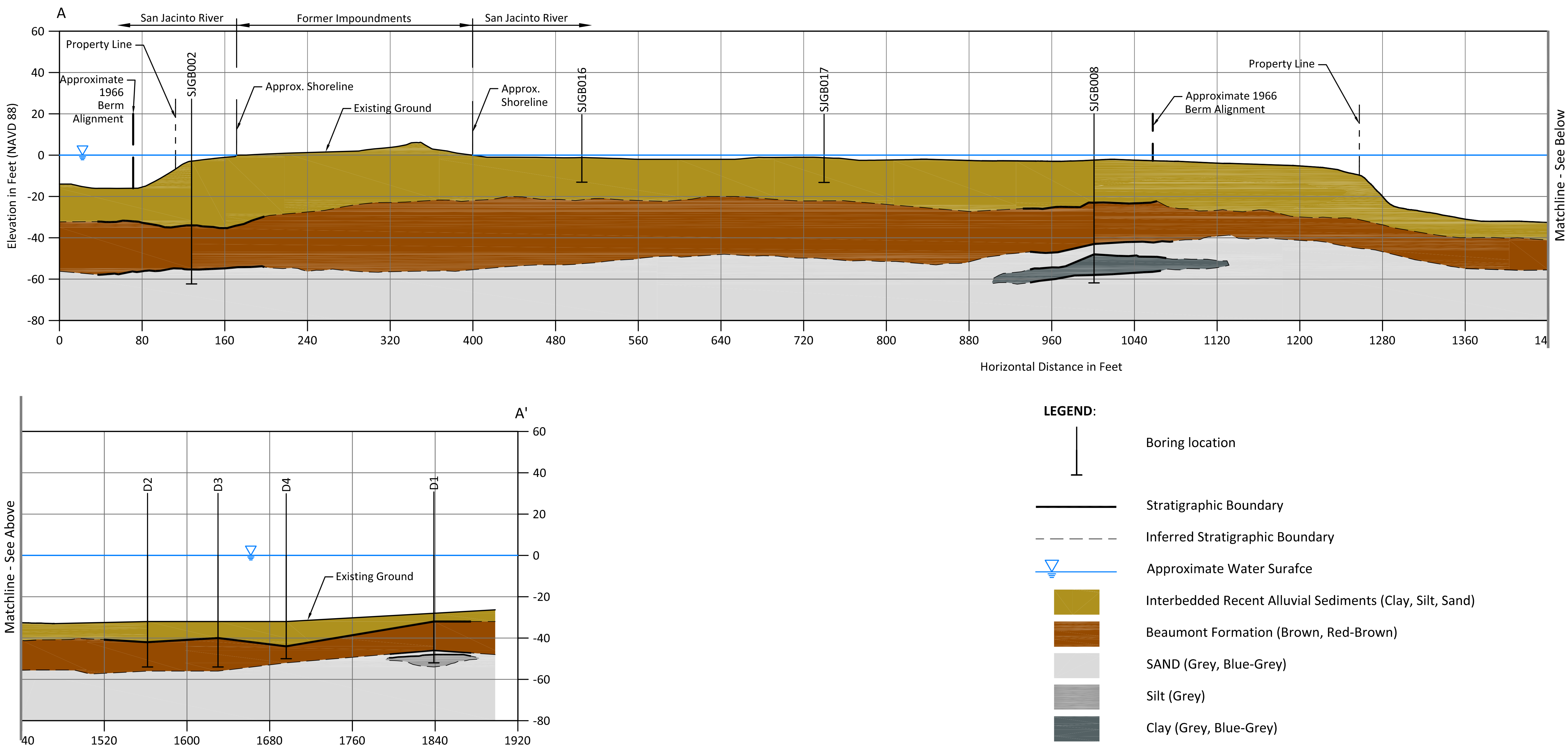
Figure 2-6

Surficial Geology and Nearby Groundwater Wells

SJRWP RI/FS Work Plan

SJRWP Superfund/ MIMC and IPC



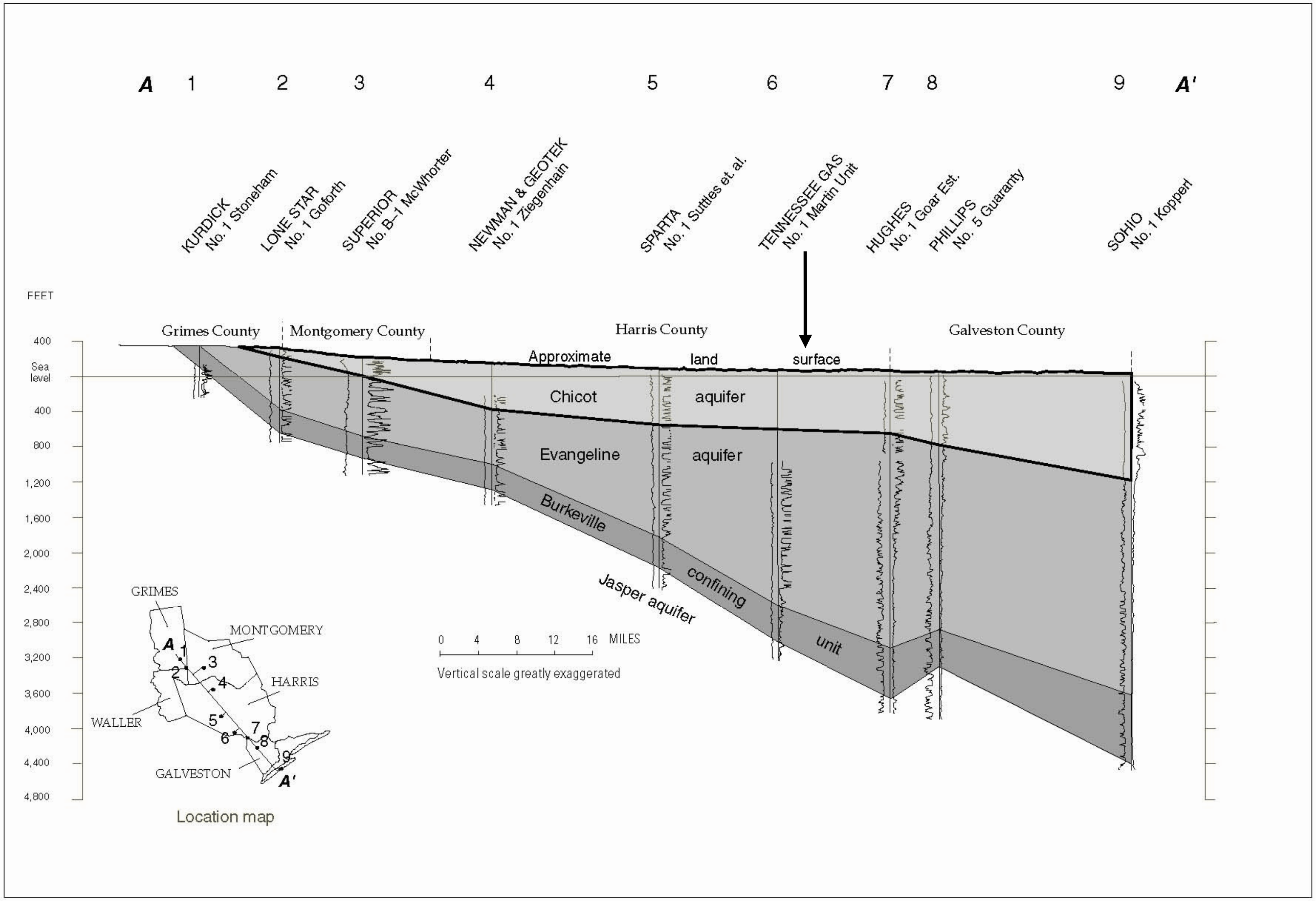
HORIZONTAL DATUM: Texas South Central NAD 83, US Survey Feet.
VERTICAL DATUM: NAVD 88.
Note:
BGS - Below Ground Surface
SJGB - Borings by MIMC / IPC
D - Borings by TxDOT

Horizontal Scale in Feet
0 100
0 50
Vertical Scale in Feet
(Vertical Exaggeration x2)

K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\09055701-RP-040.dwg FIG 2-7
Jun 25, 2010 9:25am ghowell

ANCHOR QEA

Figure 2-7
Fence Diagram A-A'
Draft RI/FS Work Plan
San Jacinto River Waste Pits Superfund Site/MIMC and IPC



From USGS, 2002

↓ Indicates approximate Site location

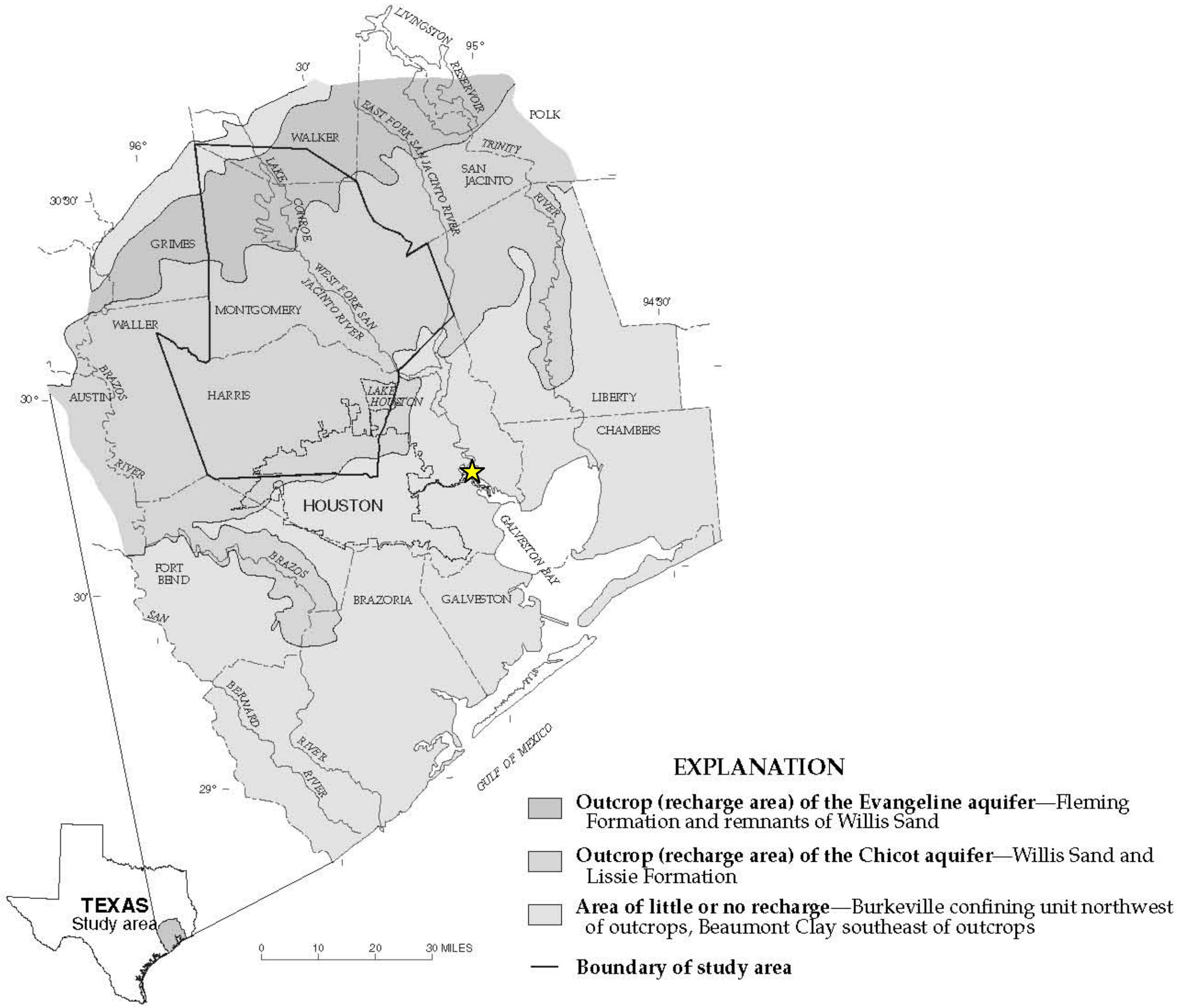
Figure 2-8

Generalized Cross-Section Showing Hydrogeologic Units of Interest in Houston, TX area

SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC

\\gfalls1\gfalls\San_Jacinto\documents\Draft_wkpl\Figure-2-8_Cross-section_20100401_MPC.docx



From USGS, 1997

Approximate Site location

Figure 2-9

Map of Recharge Areas in Chicot and Evangeline Aquifers north of Houston, TX area

SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC

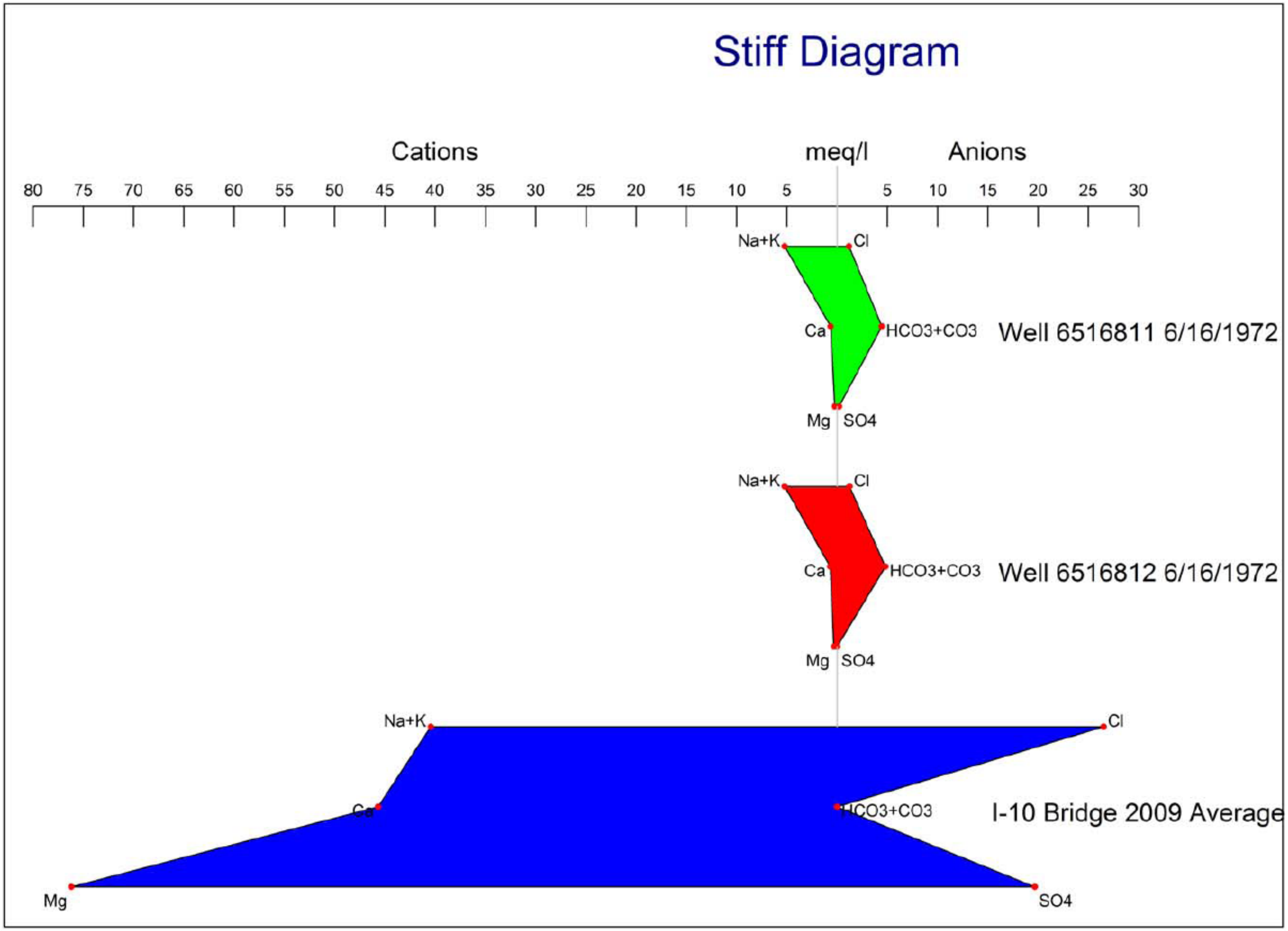
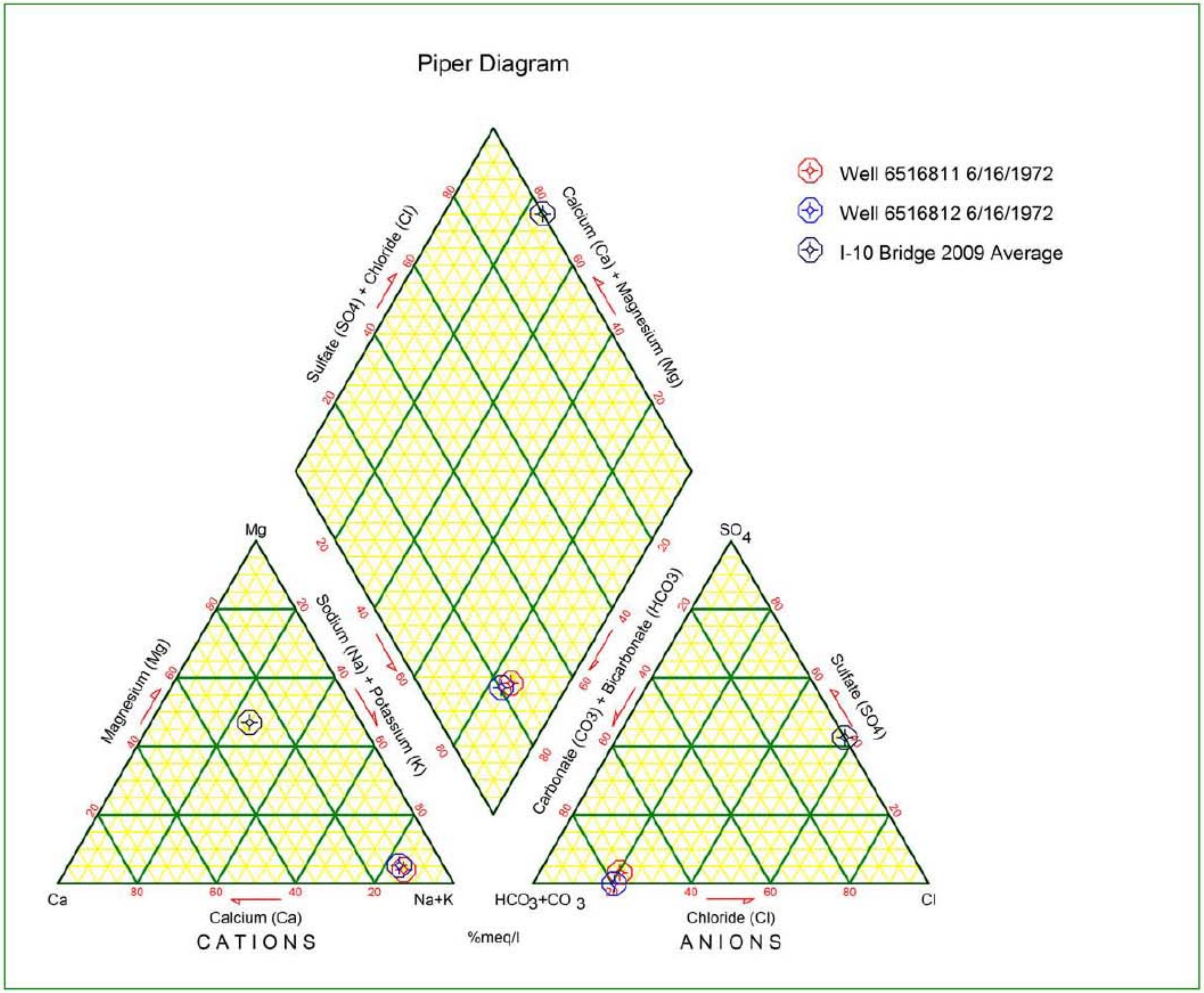
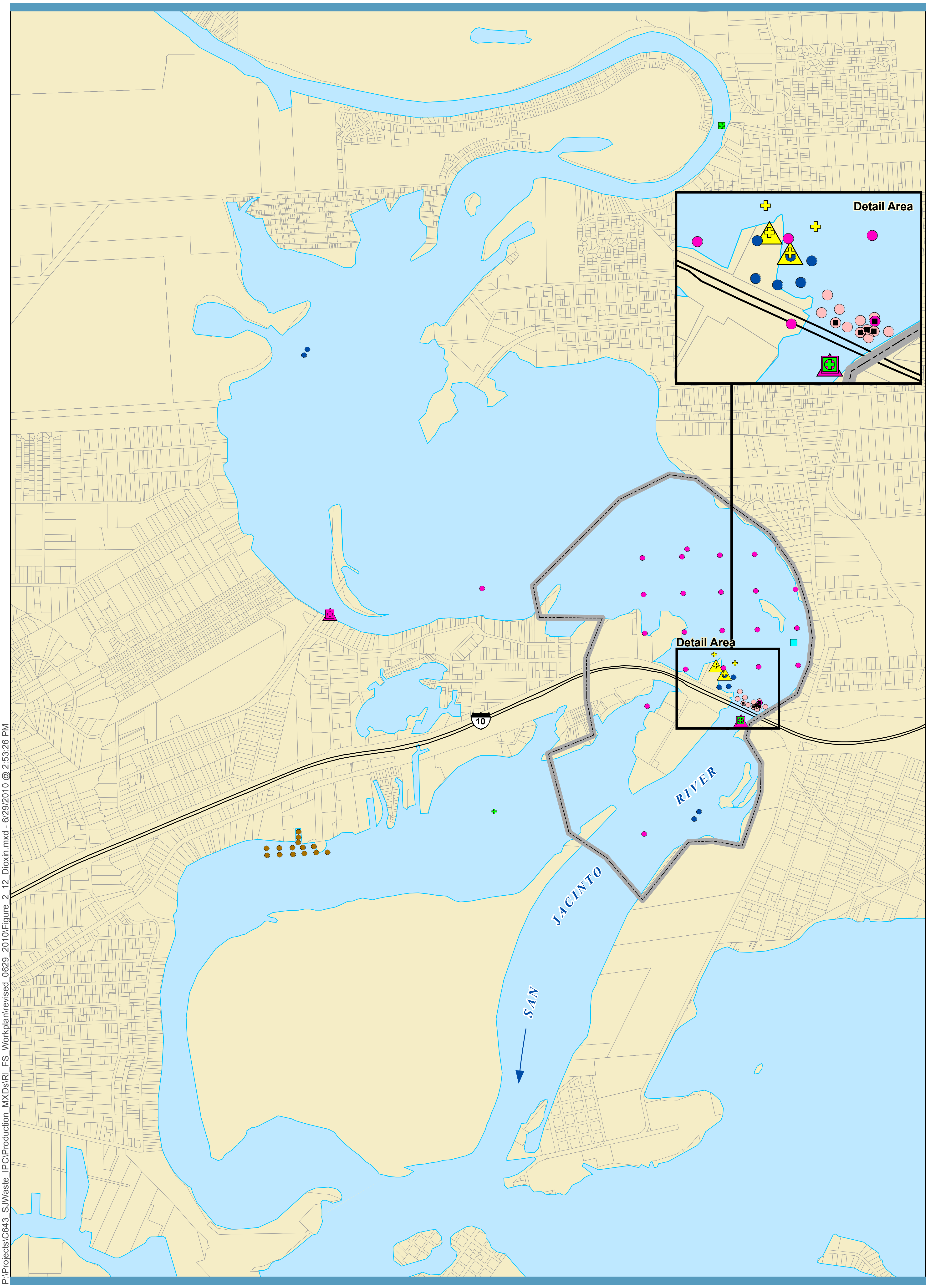


Figure 2-10
Stiff Diagrams of Private Wells and San Jacinto River
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



ANCHOR QEA integral consulting inc

Figure 2-11
Piper Diagram of Private Wells and San Jacinto River
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



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0 0.5

Scale in Miles

FEATURE SOURCES:
Parcel Boundaries:
Harris County Appraisal District
Hydrology:
Harris County Flood Control District

Preliminary Site Perimeter

Tax Parcel Boundary

Dioxin/Furans Surface Water Sample

URS (2010)

University of Houston and Parsons (2006)

Dioxin/Furans Tissue Sample

ENSR and EHA (1995)

TDSHS (2004)

University of Houston and Parsons (2006)

Dioxin/Furans Surface Sediment Sample

ENSR and EHA (1995)

TCEQ and USEPA (2006)

University of Houston and Parsons (2006)

Weston (2006)

URS (2010)

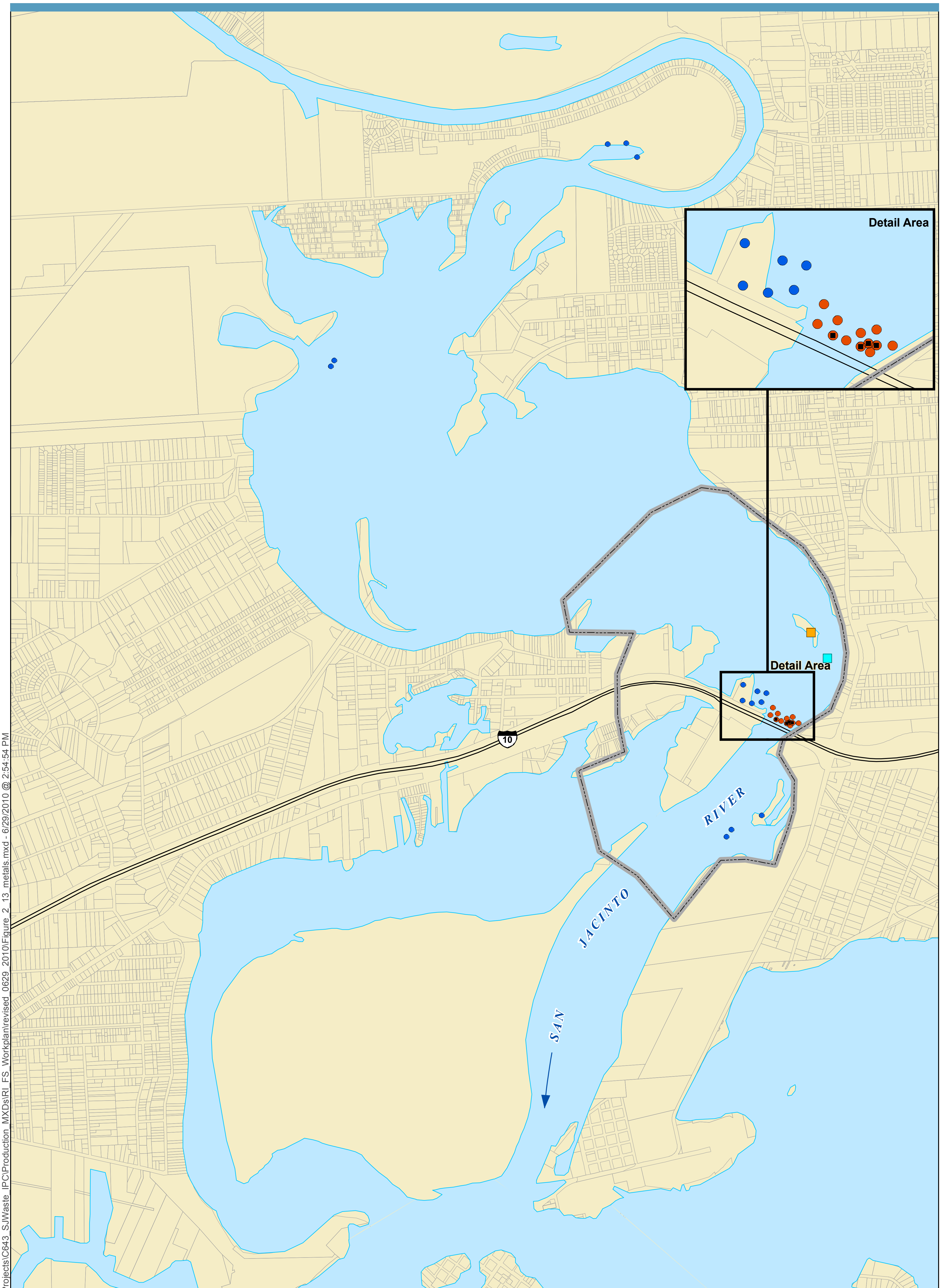
Orion (2009)

Dioxin/Furans Subsurface Sediment Sample

Co-located with surface sample; study listed above.

Figure 2-12
Dioxin Sampling Locations at the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



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0 0.5

Scale in Miles

Preliminary Site Perimeter

Tax Parcel Boundary

Metals Tissue Sample

TDSHS (1999)

TDSHS (2004)

Metals Surface Sediment Sample

TCEQ and USEPA (2006)

Weston (2006)

Metals Subsurface Sediment Sample

Co-located with surface sample; study listed above.

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-13
Metals Sampling Locations at the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

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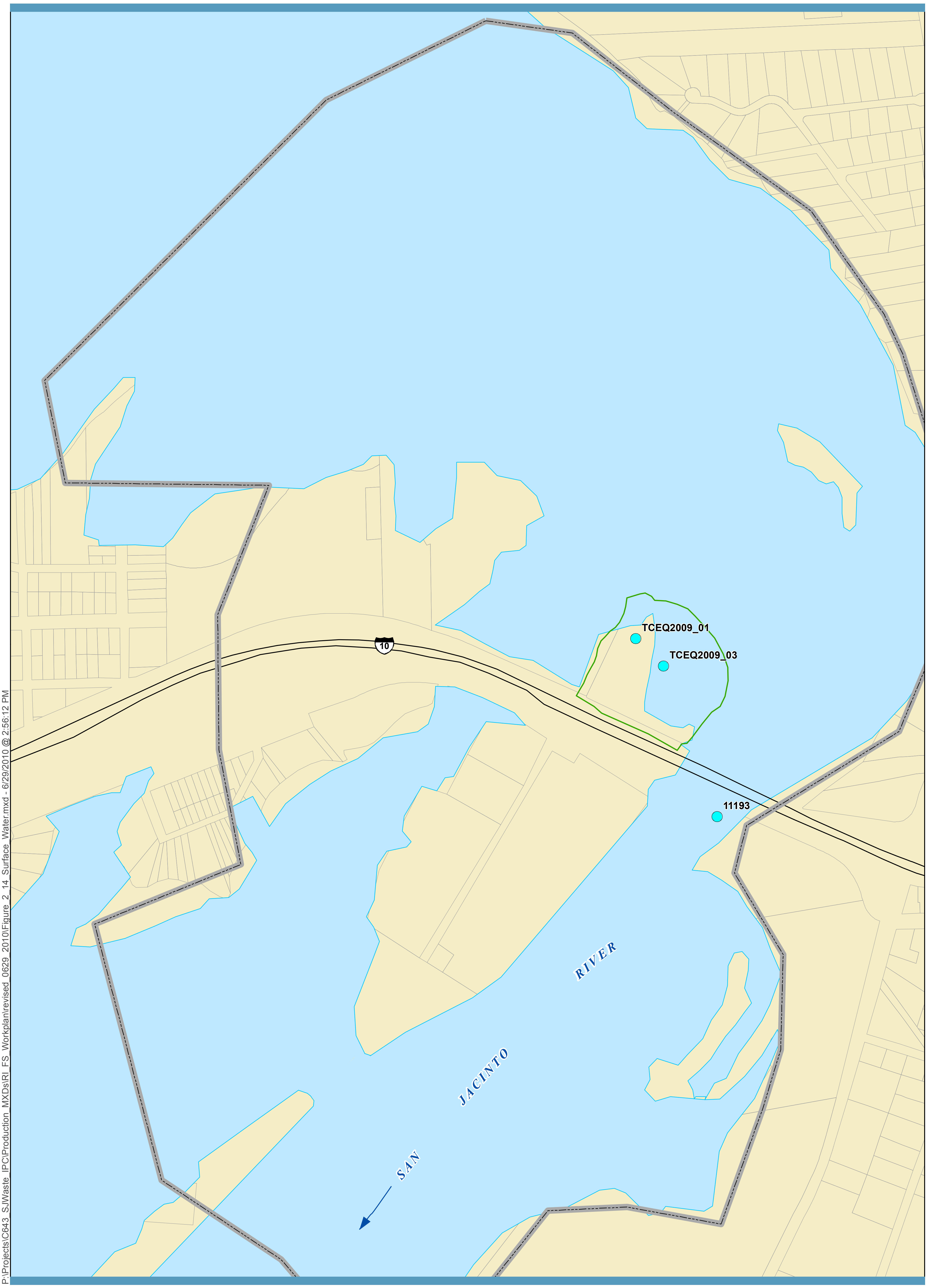

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Preliminary Site Perimeter

Tax Parcel Boundary

Original (1966) Perimeter of the Impoundments

Surface Water Sampling Location

0 800

Scale in Feet

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-14
Surface Water Locations Within the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

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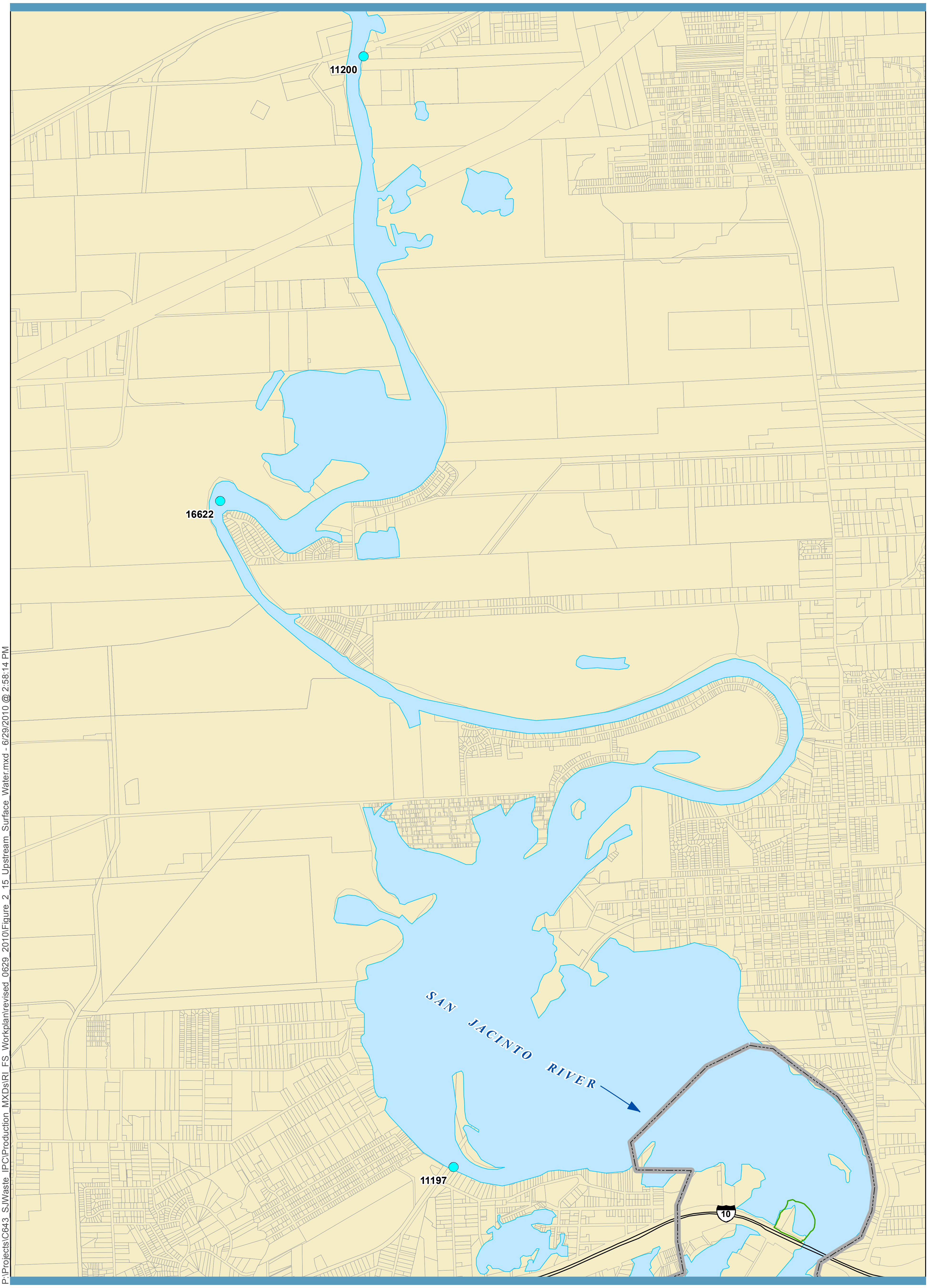
DO NOT QUOTE OR CITE



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Preliminary Site Perimeter

Tax Parcel Boundary

Original (1966) Perimeter of the Impoundments

Surface Water Sampling Location

0 0.5

Miles

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-15
Upstream Surface Water Sampling
Locations Used by the TMDL Study
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

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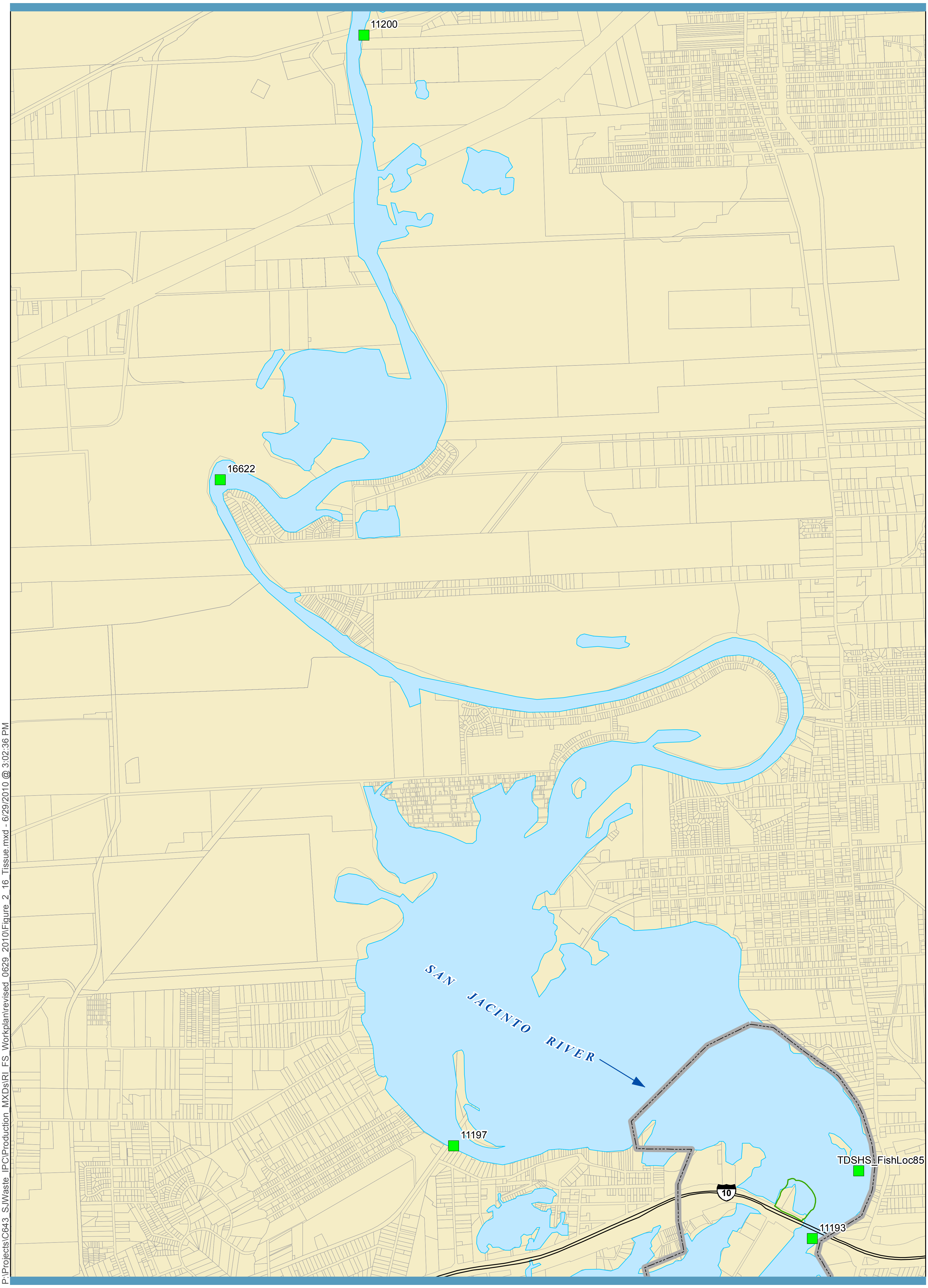
DO NOT QUOTE OR CITE



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Preliminary Site Perimeter

Tax Parcel Boundary

Original (1966) Perimeter of the Impoundments

Tissue Sample Locations

0 0.5

Miles

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

Figure 2-16

Locations of Tissue Samples Collected Between 2002 and 2004 in the Nearby Area

SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC

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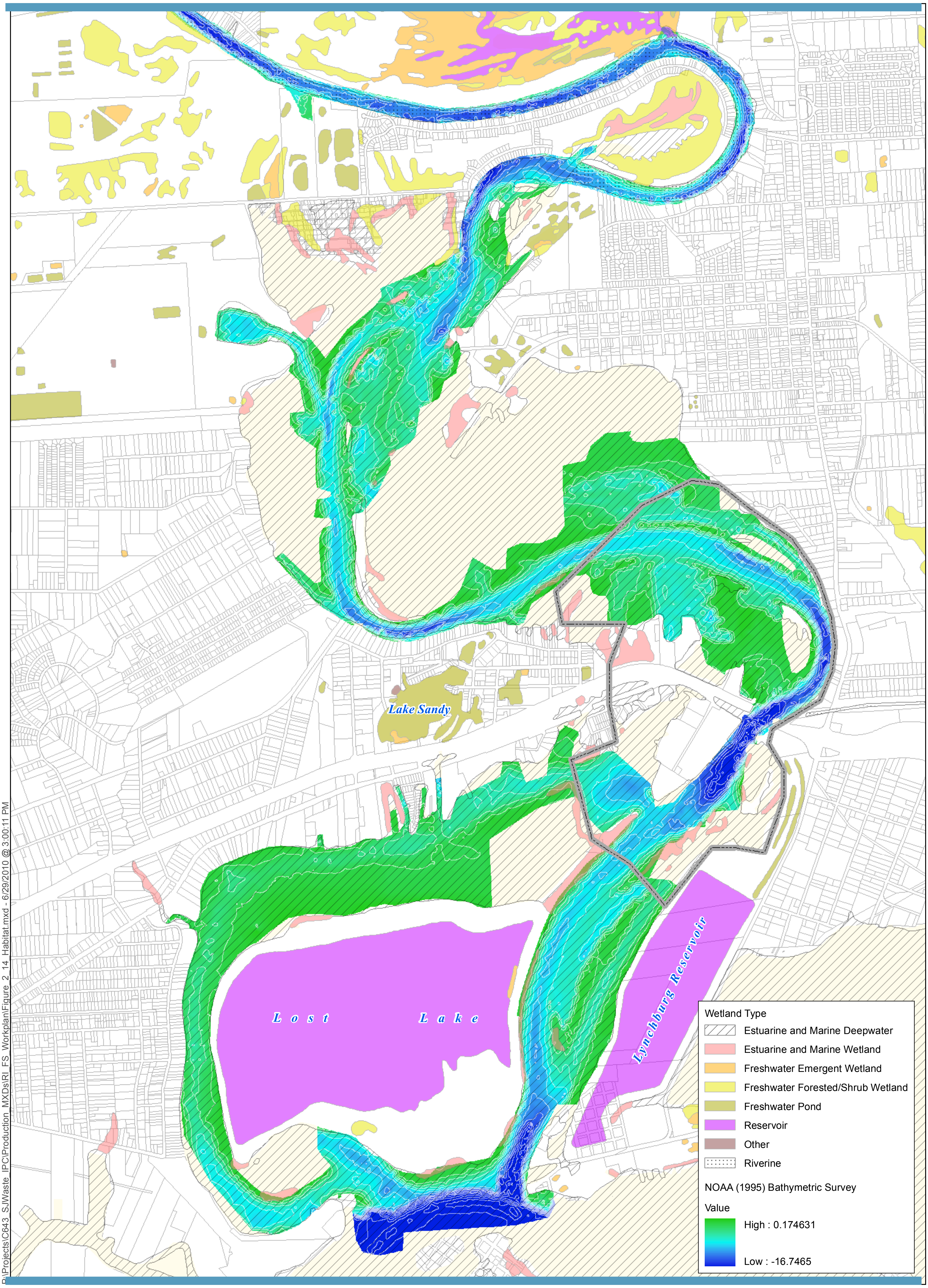

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Preliminary Site Perimeter

1-Meter 1995 Bathymetric Contour

Figure 2-17
Habitats in the Vicinity of the Site
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

0 0.125 0.25 0.5
Miles

N

FEATURE SOURCES:
Bathymetry and Contours: NOAA. 1995. Hydrographic Survey
No. H10619: in the vicinity of Lynchburg Landing to Muleshoe Lake, Texas.
Wetlands: U.S. Fish and Wildlife Service.
Parcel Boundaries: Harris County Appraisal District.

DRAFT
DO NOT QUOTE OR CITE

Figure 2-18
1718 Map, Guillaume Delisle (David Rumsey Map Collection)
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Figure 2-19
1944 Aerial Photograph
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

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Figure 2-20
1957 Aerial Photograph
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

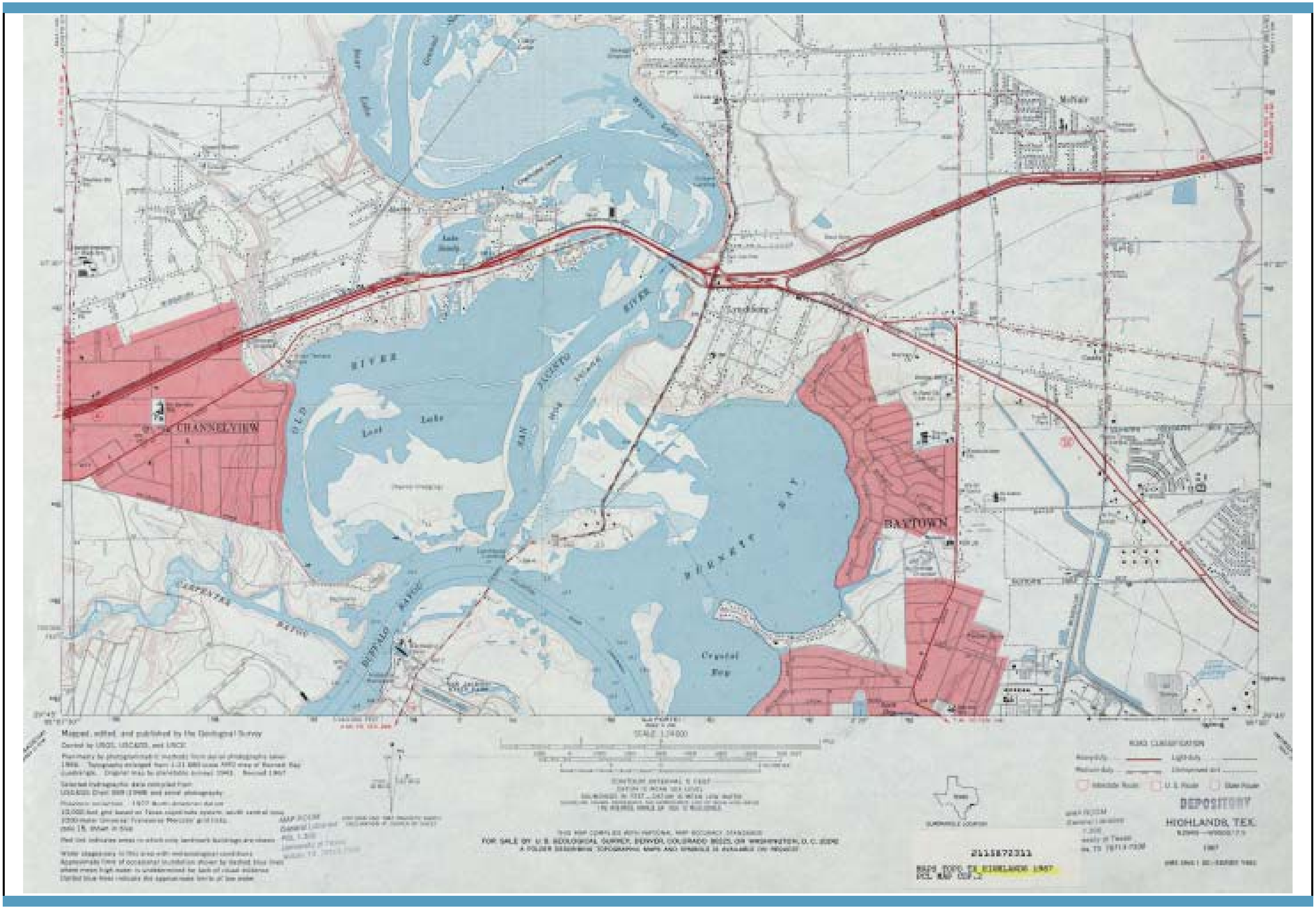
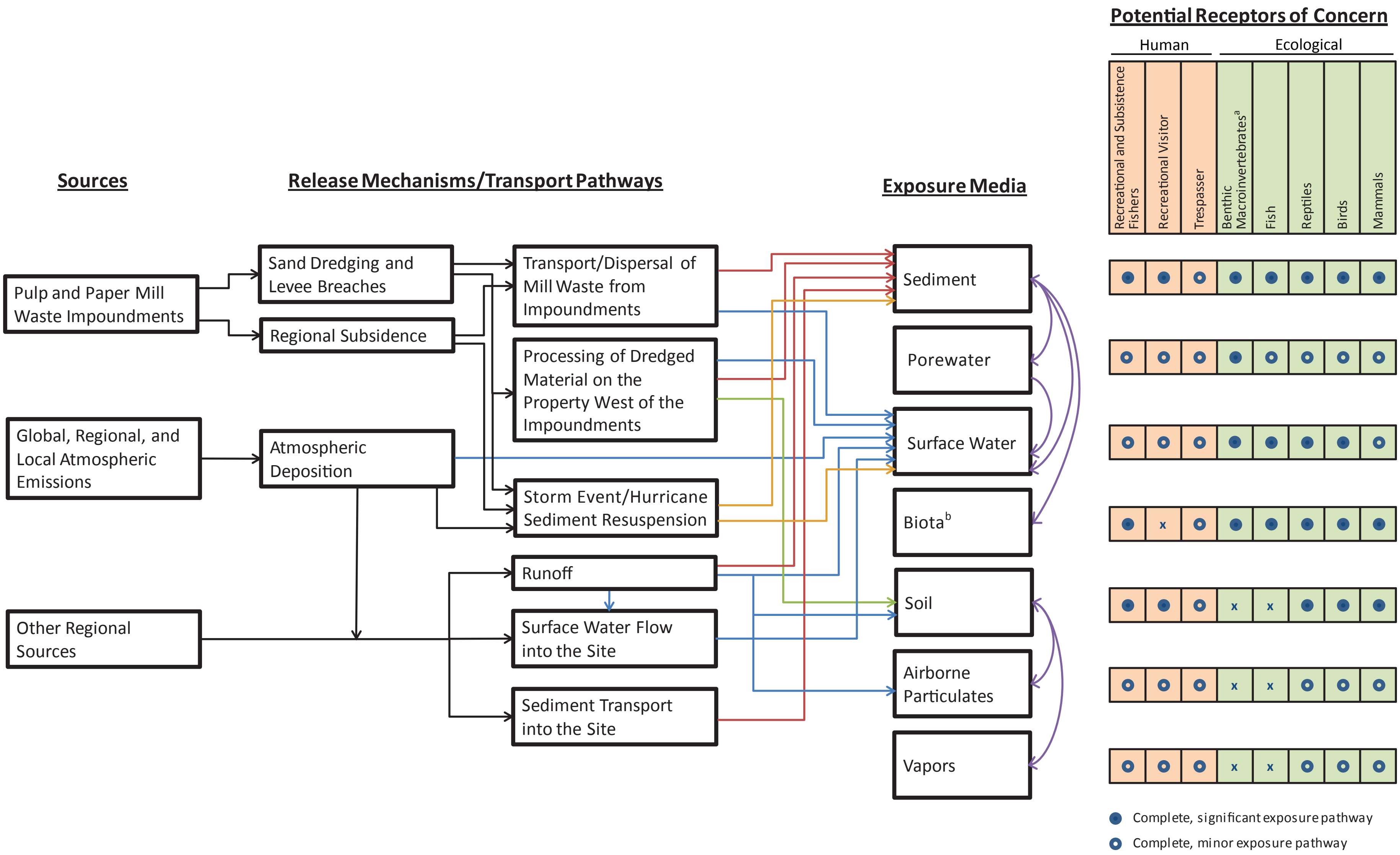


Figure 2-21
1967 Topographic Map
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



Notes:

Other regional sources may include industrial effluents, publicly owned treatment works, and stormwater.

Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.

[a]Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds and mammals.

[b]Biota consumed by human receptors are expected to be fish and shellfish.

Figure 4-1
CSM Pathway Diagram
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

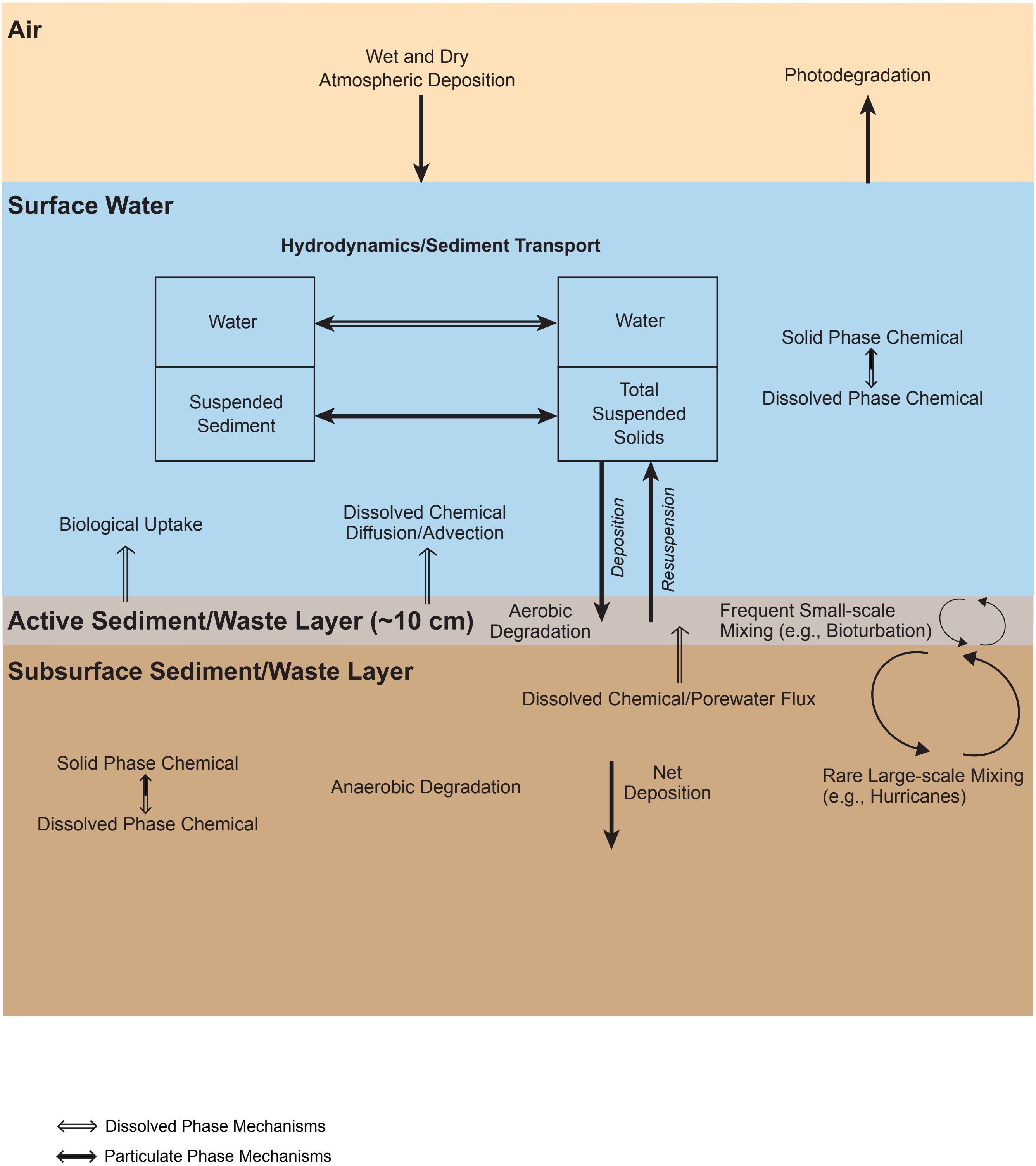
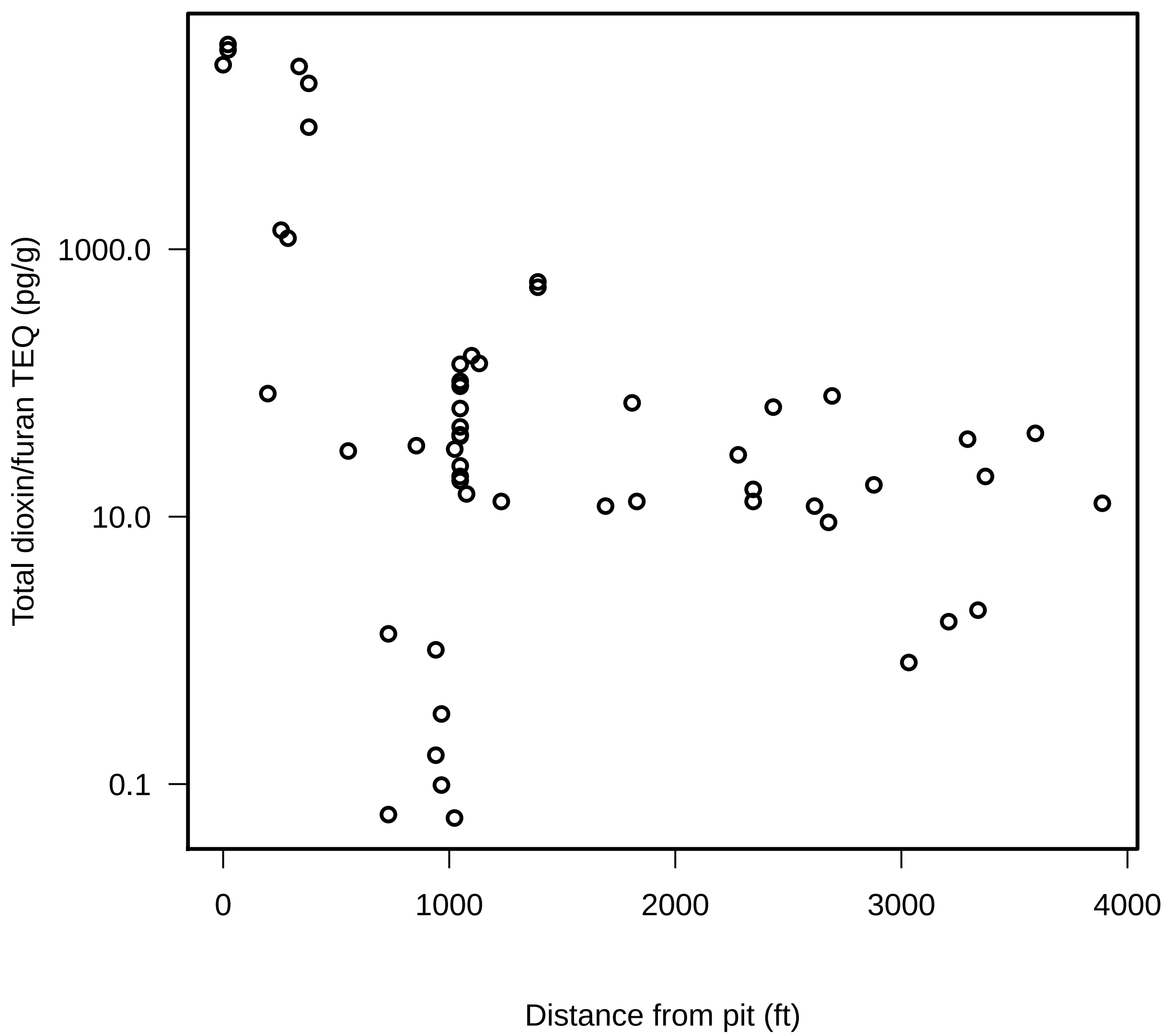


Figure 4-2
Physical/Chemical Fate and Transport Processes
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC



TEQ – toxicity equivalent

Figure 4-3
Change in Toxicity Equivalent Concentration with Distance from the San Jacinto Impoundment
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Potential Human Receptors of Concern

Exposure Media	Exposure Route	Recreational and Subsistence Fishers	Recreational Visitor	Trespasser
Sediment	Ingestion	●	●	○
	Dermal Contact	●	●	○
Porewater	Dermal Contact	○	○	○
Surface Water	Ingestion	○	○	○
	Dermal Contact	○	○	○
Fish and Shellfish	Ingestion	●	x	○
Soil	Ingestion	●	●	○
	Dermal Contact	●	●	○
Airborne Particulates	Inhalation	○	○	○
Vapors	Inhalation	○	○	○

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

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Figure 4-4
Conceptual Site Model for Human Health
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Potential Receptors of Concern

Exposure Media	Exposure Routes	Ecological: Benthic Macroinvertebrates[a]	Ecological: Fish	Ecological: Reptiles	Ecological: Birds	Ecological: Mammals
Sediment	Ingestion	●	●	●	●	●
	Direct Contact	●	○	○	○	○
Porewater	Ingestion	●	○	x	○	x
	Direct Contact	●	○	○	○	○
	Respiration	●	○	x	x	x
Surface Water	Ingestion[b]	●	●	●	●	x
	Direct Contact	●	○	○	○	○
	Respiration	●	●	x	x	x
Biota	Ingestion	●	●	●	●	●
Soil	Ingestion	x	x	●	●	●
	Direct Contact	x	x	○	○	○
Airborne Particulates	Inhalation	x	x	○	○	○

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

Notes:

[a]Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds, and mammals.

[b]Mammals and terrestrial birds are assumed not to ingest surface water for drinking, as surface water is estuarine.

Figure 4-5
Conceptual Site Model for Ecological Exposures
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

Exposure Media	Exposure Routes	Benthic Macro-invertebrates	Fish		Reptiles	Aquatic Birds		Terrestrial Birds	Mammals
			Omnivores	Benthic Piscivores		Piscivore	Wading Invertivores/ Omnivores	Invertivore	
Sediment	Ingestion	●	○	●	●	●	●	x	●
	Direct Contact	●	○	○	○	○	●	x	○
Porewater	Ingestion	●	○	○	x	○	○	○	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	○	○	x	x	x	x	x
Surface Water	Ingestion[a]	●	●	●	●	●	●	x	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	●	●	x	x	x	x	x
Biota	Ingestion	●	●	●	●	●	●	●	●
Soils	Ingestion	x	x	x	●	x	x	●	●
	Direct Contact	x	x	x	○	○	○	○	○
Airborne Particulates	Inhalation[b]	x	x	x	○	○	○	○	○

Notes:

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

[a] Mammals and terrestrial birds are assumed not to ingest surface water for drinking, as surface water is estuarine.

[b] Inhalation of contaminated vapor or particles is a minor exposure route for reptiles, birds, and mammals.

Figure 4-6

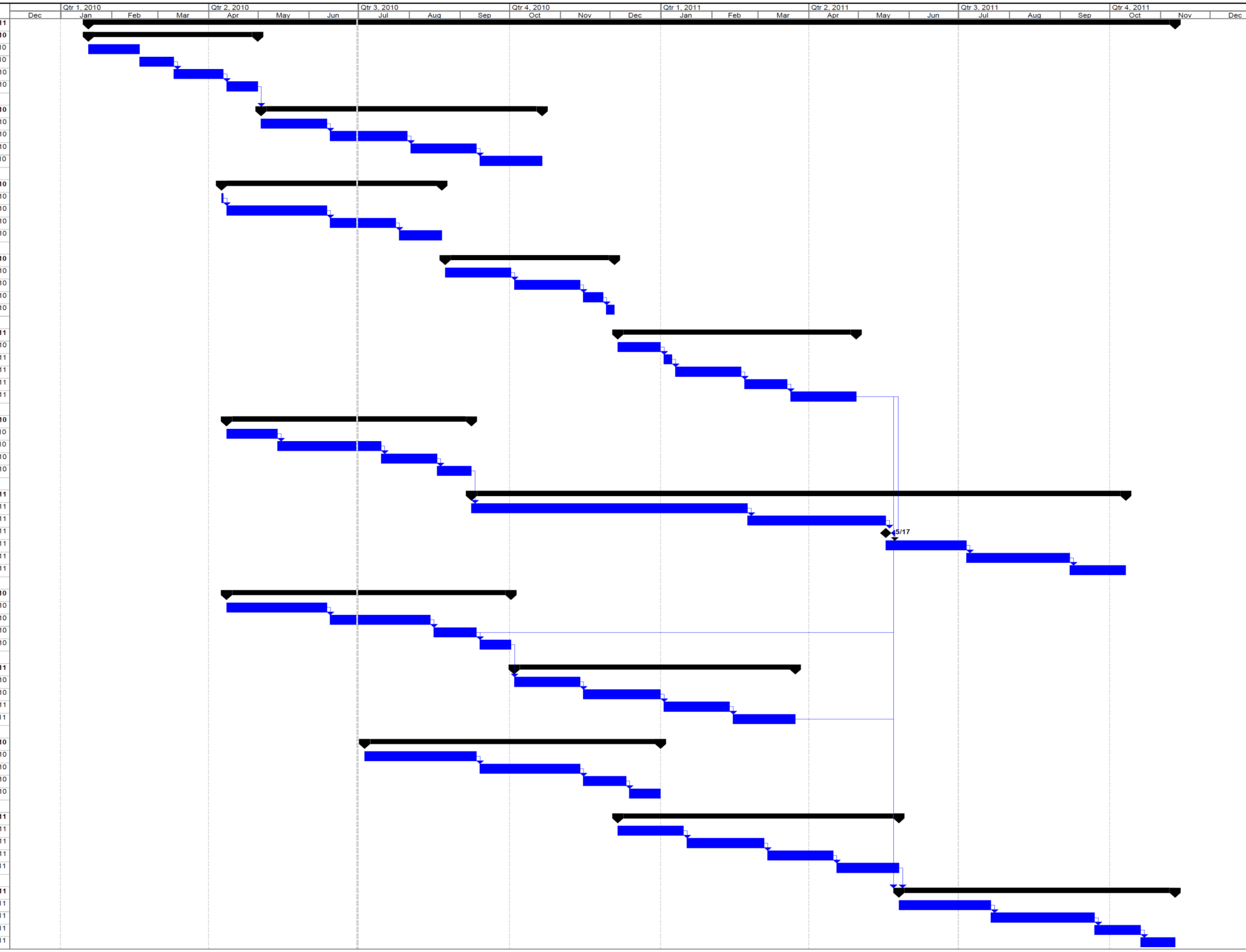
Conceptual Site Model for Ecological Exposures:

Exposure Details for Receptor Feeding Guilds and Habitat Associations

SJRWP RI/FS Work Plan

SJRWP Superfund/MIMC and IPC

ID	Task Name	Duration	Start	Finish
1	**Preliminary Site Characterization Report Studies and Preparation**	**473 days**	**Mon 1/18/10**	**Wed 11/9/11**
2	**San Jacinto Sediment Sampling and Analysis Plan**	**75 days**	**Mon 1/18/10**	**Fri 4/30/10**
3	Draft Sediment QAPP/FSP	23 days	Mon 1/18/10	Wed 2/17/10
4	Agency Review	15 days	Thu 2/18/10	Wed 3/10/10
5	Final Sediment SAP Submitted	22 days	Thu 3/11/10	Fri 4/9/10
6	EPA Approval of Sediment SAP	15 days	Mon 4/12/10	Fri 4/30/10
7				
8	**Field Sampling, Sediment Study**	**123 days**	**Mon 5/3/10**	**Wed 10/20/10**
9	Mobilization/Field Implementation	30 days	Mon 5/3/10	Fri 6/11/10
10	Laboratory Analysis	35 days	Mon 6/14/10	Fri 7/30/10
11	Data Validation	30 days	Mon 8/2/10	Fri 9/10/10
12	Data Management	28 days	Mon 9/13/10	Wed 10/20/10
13				
14	**RI/FS Work Plan and SLERA**	**96 days**	**Fri 4/9/10**	**Fri 8/20/10**
15	Draft of Work Plan and SLERA	1 day	Fri 4/9/10	Fri 4/9/10
16	Agency Review	45 days	Mon 4/12/10	Fri 6/11/10
17	Final RI/FS Work Plan and SLERA	30 days	Mon 6/14/10	Fri 7/23/10
18	EPA Approval of RI/FS Work Plan	20 days	Mon 7/26/10	Fri 8/20/10
19				
20	**Groundwater QAPP/FSP**	**75 days**	**Mon 8/23/10**	**Fri 12/3/10**
21	Draft Groundwater QAPP/FSP	30 days	Mon 8/23/10	Fri 10/1/10
22	Agency Review	30 days	Mon 10/4/10	Fri 11/12/10
23	Final Groundwater QAPP/FSP Submitted	10 days	Mon 11/15/10	Fri 11/26/10
24	EPA Approval of Groundwater QAPP/FSP	5 days	Mon 11/29/10	Fri 12/3/10
25				
26	**Field Sampling, Groundwater**	**105 days**	**Mon 12/6/10**	**Fri 4/29/11**
27	Mobilization/Well Installation	20 days	Mon 12/6/10	Fri 12/31/10
28	Sampling	5 days	Mon 1/3/11	Fri 1/7/11
29	Laboratory Analysis	30 days	Mon 1/10/11	Fri 2/18/11
30	Data Validation	20 days	Mon 2/21/11	Fri 3/18/11
31	Data Management	30 days	Mon 3/21/11	Fri 4/29/11
32				
33	**Technical Memorandum on Fate & Transport Modeling**	**107 days**	**Mon 4/12/10**	**Tue 9/7/10**
34	Draft Tech Memo on Fate & Transport Modeling & QAPP/FSP	23 days	Mon 4/12/10	Wed 5/12/10
35	Agency Review	45 days	Thu 5/13/10	Wed 7/14/10
36	Final Tech. Memo. and QAPP/FSP Submitted	24 days	Thu 7/15/10	Tue 8/17/10
37	EPA Approval of Tech. Memo. On Fate&Transport Modeling Memo and QAPP/FSP	15 days	Wed 8/18/10	Tue 9/7/10
38				
39	**Field Sampling, Fate &Transport Study**	**284 days**	**Wed 9/8/10**	**Mon 10/10/11**
40	Mobilization and Field Study	120 days	Wed 9/8/10	Tue 2/22/11
41	Calibrate/Validate and Test Models	60 days	Wed 2/23/11	Tue 5/17/11
42	Model Presentation	0 days	Tue 5/17/11	Tue 5/17/11
43	Submit Draft F&T Modeling Report	35 days	Wed 5/18/11	Tue 7/5/11
44	Agency Review and Response	45 days	Wed 7/6/11	Tue 9/6/11
45	Final F&T Modeling Report	24 days	Wed 9/7/11	Mon 10/10/11
46				
47	**Technical Memorandum on Bioaccumulation**	**125 days**	**Mon 4/12/10**	**Fri 10/1/10**
48	Draft Tech. Memo. on Bioaccumulation & QAPP/FSP	45 days	Mon 4/12/10	Fri 6/11/10
49	Agency Review	45 days	Mon 6/14/10	Fri 8/13/10
50	Final Tech Memo on Bioaccumulation Submitted	20 days	Mon 8/16/10	Fri 9/10/10
51	EPA Approval of Tech Memo on Bioaccumulation & QAPP/FSP	15 days	Mon 9/13/10	Fri 10/1/10
52				
53	**Field Sampling Tissue**	**123 days**	**Mon 10/4/10**	**Wed 3/23/11**
54	Mobilization and Field Study	30 days	Mon 10/4/10	Fri 11/12/10
55	Laboratory Analysis	35 days	Mon 11/15/10	Fri 12/31/10
56	Data Validation	30 days	Mon 1/3/11	Fri 2/11/11
57	Data Management	28 days	Mon 2/14/11	Wed 3/23/11
58				
59	**Soil QAPP/FSP**	**130 days**	**Mon 7/5/10**	**Fri 12/31/10**
60	Draft Soil QAPP/FSP	50 days	Mon 7/5/10	Fri 9/10/10
61	Agency Review	45 days	Mon 9/13/10	Fri 11/12/10
62	Final Soil QAPP/FSP Submitted	20 days	Mon 11/15/10	Fri 12/10/10
63	EPA Approval of Soil QAPP/FSP	15 days	Mon 12/13/10	Fri 12/31/10
64				
65	**Field Sampling Soil**	**123 days**	**Mon 12/6/10**	**Wed 5/25/11**
66	Mobilzation and Field Study	30 days	Mon 12/6/10	Fri 1/14/11
67	Laboratory Analysis	35 days	Mon 1/17/11	Fri 3/4/11
68	Data Validation	30 days	Mon 3/7/11	Fri 4/15/11
69	Data Management	28 days	Mon 4/18/11	Wed 5/25/11
70				
71	**Preliminary Site Characterization Report**	**120 days**	**Thu 5/26/11**	**Wed 11/9/11**
72	Draft PSC Report	40 days	Thu 5/26/11	Wed 7/20/11
73	Agency Review	45 days	Thu 7/21/11	Wed 9/21/11
74	Final PSC Report Submitted	20 days	Thu 9/22/11	Wed 10/19/11
75	EPA Approval of PSC Report	15 days	Thu 10/20/11	Wed 11/9/11



Project: Draft San Jac Schedule Pre-P
Date: Wed 6/30/10

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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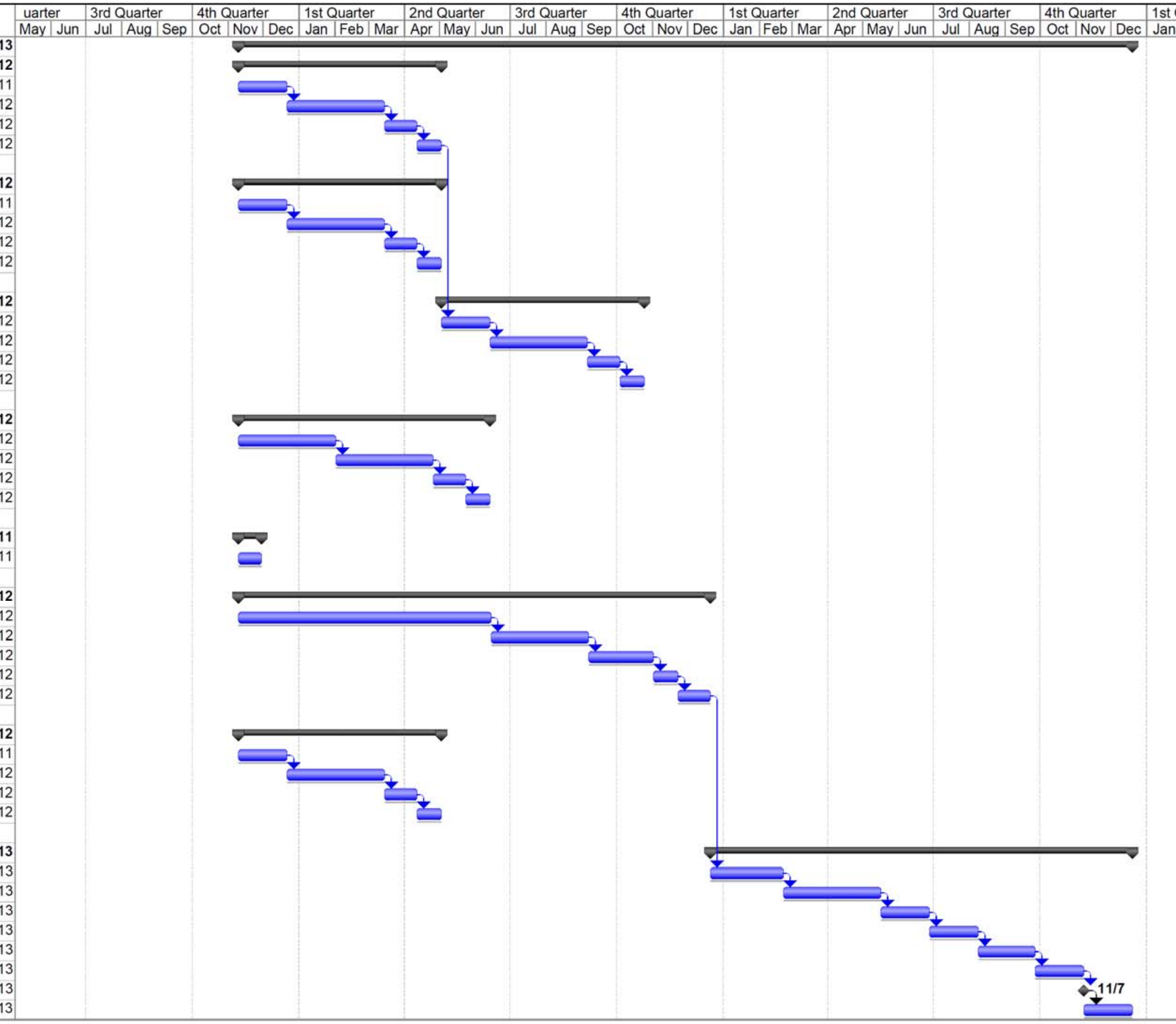
Figure 8-1a
Schedule of Deliverables Pre Preliminary Site Characterization Report
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMC and IPC

ID	Task Name	Duration	Start	Finish
1	**Post Site Characterization Report Deliverables**	**551 days**	**Thu 11/10/11**	**Thu 12/19/13**
2	**Exposure Assessment (EA) Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
3	Submit Draft of EA Memo	30 days	Thu 11/10/11	Wed 12/21/11
4	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
5	Final EA Memorandum Submitted	20 days	Thu 3/15/12	Wed 4/11/12
6	EPA Approval of EA Memorandum	15 days	Thu 4/12/12	Wed 5/2/12
7				
8	**Toxicological and Epidemiological Studies (TES) Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
9	Submit Draft of TES Memo	30 days	Thu 11/10/11	Wed 12/21/11
10	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
11	Final TES Memorandum Submitted	20 days	Thu 3/15/12	Wed 4/11/12
12	EPA Approval of TES Memorandum	15 days	Thu 4/12/12	Wed 5/2/12
13				
14	**Baseline Human Health Risk Assessment BHHRA Report**	**125 days**	**Thu 5/3/12**	**Wed 10/24/12**
15	Submit Draft of BHHRA Report	30 days	Thu 5/3/12	Wed 6/13/12
16	Agency Review	60 days	Thu 6/14/12	Wed 9/5/12
17	Final BHHRA Submitted	20 days	Thu 9/6/12	Wed 10/3/12
18	EPA Approval of BHHRA Memorandum	15 days	Thu 10/4/12	Wed 10/24/12
19				
20	**Baseline Ecological Risk Assessment (BERA) Report**	**155 days**	**Thu 11/10/11**	**Wed 6/13/12**
21	Submit Draft of BERA Report	60 days	Thu 11/10/11	Wed 2/1/12
22	Agency Review	60 days	Thu 2/2/12	Wed 4/25/12
23	Final BERA Submitted	20 days	Thu 4/26/12	Wed 5/23/12
24	EPA Approval of BERA Memorandum	15 days	Thu 5/24/12	Wed 6/13/12
25				
26	**Treatability Studies (TS)**	**14 days**	**Thu 11/10/11**	**Tue 11/29/11**
27	To be determined	14 days	Thu 11/10/11	Tue 11/29/11
28				
29	**Remedial Investigation (RI) Report**	**291 days**	**Thu 11/10/11**	**Thu 12/20/12**
30	Submit Draft of RI Report	156 days	Thu 11/10/11	Thu 6/14/12
31	Agency Review	60 days	Fri 6/15/12	Thu 9/6/12
32	Final RI Report Submitted	40 days	Fri 9/7/12	Thu 11/1/12
33	Presentation to EPA of RI Report	15 days	Fri 11/2/12	Thu 11/22/12
34	EPA Approval of RI Report	20 days	Fri 11/23/12	Thu 12/20/12
35				
36	**Remedial Alternatives Memorandum**	**125 days**	**Thu 11/10/11**	**Wed 5/2/12**
37	Submit Draft of RA Memorandum	30 days	Thu 11/10/11	Wed 12/21/11
38	Agency Review	60 days	Thu 12/22/11	Wed 3/14/12
39	Prepare Final Draft RA Report	20 days	Thu 3/15/12	Wed 4/11/12
40	EPA Approval of Final RA Report	15 days	Thu 4/12/12	Wed 5/2/12
41				
42	**Feasibility Study (FS) Report**	**260 days**	**Fri 12/21/12**	**Thu 12/19/13**
43	Submit Draft Interim Final FS Report	45 days	Fri 12/21/12	Thu 2/21/13
44	Agency Review	60 days	Fri 2/22/13	Thu 5/16/13
45	Final Interim FS Report	30 days	Fri 5/17/13	Thu 6/27/13
46	Submit Final FS Report	30 days	Fri 6/28/13	Thu 8/8/13
47	EPA Prepares "Proposed Plan"	35 days	Fri 8/9/13	Thu 9/26/13
48	EPA Accepts Public Comment on Proposed Plan	30 days	Fri 9/27/13	Thu 11/7/13
49	EPA Provides Comments to Respondents	0 days	Thu 11/7/13	Thu 11/7/13
50	Prepare Final FS Report	30 days	Fri 11/8/13	Thu 12/19/13



Project: EPAs UAO-RI Schedule after
Date: Thu 9/2/10

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

Page 1

Figure 8-1b
Schedule of Deliverables Post Preliminary Site Characterization Report
SJRWP RI/FS Work Plan
SJRWP Superfund/MIMIC and IPC

APPENDIX A
DRAFT DATA MANAGEMENT PLAN
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
COC	chain-of-custody
DMP	Data Management Plan
EDD	electronic data deliverable
FSP	Field Sampling Plan
GIS	geographic information system
GPS	global positioning system
RI/FS	Remedial Investigation and Feasibility Study
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This data management plan (DMP) specifies procedures and standards that will be used to handle environmental measurement data and related information for the San Jacinto River Waste Pits Remedial Investigation and Feasibility Study (RI/FS). Data management tasks will be carried out throughout the RI/FS process and include acquiring and organizing data, administering the project database, managing geographic information system (GIS) files, supporting data validation, managing project documents, and summarizing data for use in analyses and reports. Information to be managed includes a wide range of data types, from field data sheets and logbooks to final reports.

The following topics are covered in this DMP:

- An overview of project data management
- Project data flow
- Project database
- Workflows for handling different types of data
- Documentation and record keeping
- Communication and data sharing

2 OVERVIEW OF PROJECT DATA MANAGEMENT

An RI/FS includes a number of distinct activities, such as sample collection, laboratory analysis, data validation, data interpretation (e.g., nature and extent characterization and risk assessment), and report production. Many of these activities have clearly defined beginning and ending points during the course of the project. In contrast, data management processes occur throughout all phases of the RI/FS, as part of or underlying these other activities. The data management processes that accompany each of these other activities differ, however. Table A-1 summarizes the major activities that occur during an RI/FS and the corresponding data management processes. The principal data management processes are described in the following sections.

2.1 Implement the Project Database

Based on the scope of work specified in the Unilateral Administrative Order, Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to International Paper Company and McGinnes Industrial Maintenance Corporation on November 20, 2009, a project database must be set up that is capable of accommodating all of the data to be collected. This step must be completed early in the RI/FS process because analysis of existing data sets is necessary to help develop the Work Plan, and those analyses can be conducted most effectively and efficiently when existing data have been assembled into a single coherent format—i.e., a database.

Activities carried out during implementation of the project database generally include:

- Initiation of a project-specific instance of a general purpose environmental database (database development is not required; Integral will use a model database that it has developed specifically for projects like this one)
- Establishment of backup procedures for the database
- Initialization of the database with lists and definitions of valid values for the types of samples, analytes, and results that will be measured
- Establishment of access controls on the database so that only appropriately qualified staff can access or update the database

2.2 Acquire Existing Site Data

Data that have been previously collected from the Site that are relevant to the analyses to be carried out in the RI/FS will be obtained and loaded into the project database. Data management activities carried out during this process include:

- Acquisition of data tables and documents, and discussions with original investigators, as necessary to compile detailed information on sampling locations, dates, and depths; methods; detection limits; measurement bases; and concentrations
- Acquisition of relevant spatial data to provide context for analytical measurements made at the Site and in the surrounding region
- Reformatting and loading those data into the project database
- Review of the data and execution of quality assurance checks to ensure that the entered data are correct and complete

After existing data have been acquired, the quality of these data will be assessed for use in the RI/FS process (as described in Section 3.1 of the RI/FS Work Plan).

2.3 Summarize Data for Project Planning

Data management activities carried out to support project planning include:

- Recording planned sampling information in a way that allows later quality assurance checks
- Ensuring that the types of data collected, the data structures used, and the data retrieval and summarization tools will all be able to support the planned data uses
- Organizing historical data as necessary so that it is in a consistent and well documented format consistent with planned data uses
- Acquiring, organizing, transforming, and documenting the regional and Site-specific spatial data needed to support data analysis and interpretation

The overall project plan is documented in the RI/FS Work Plan and the Quality Assurance Project Plan, which will be reviewed and approved by USEPA.

2.4 Establish Electronic Data Deliverable Reporting Specifications

Analytical results will be provided by the laboratories in electronic data deliverable (EDD) formats that are specifically designed to facilitate loading of data into the project database. These specifications will be provided to the laboratories, and support provided to the laboratories in the production of appropriate deliverables.

2.5 Integrate Field Sampling Results

Data management activities carried out to support field sampling include:

- Preparation of guidance and support materials, including maps and specifications for assignment of sample identifiers
- Receipt, entry, and quality assurance checks of sampling information from field logbooks, sampling forms, and global positioning system (GPS) devices
- Filing of hard copy materials

2.6 Integrate Laboratory Analysis Results

Integration of laboratory results into the project database will include the following procedures:

- Review of EDDs provided by the laboratory to identify erroneous formats or missing or discrepant data; discrepancies will be resolved in cooperation with the laboratory
- Loading of data from EDDs into the project database and assignment of initial values for significant digits data validation status, and data quality level

2.7 Summarize Data for Validation and Integrate Validation Results

Data management activities carried out to support data validation include:

- Preparation of summaries of sampling information, analytical results for field samples, and analytical results for laboratory quality control samples, for use by data validators
- Updating of the database with data validation results, and quality assurance checks of the updates
- Updating of the data validation status and data quality level
- Filing of hard copy materials
- Preparation of data tables for data validation reporting

2.8 Maintain the Project Library

Data management activities carried out in support of document management include:

- Document acquisition and transformation (e.g., scanning and text extraction) as necessary
- Entry into the database of document citations, abstracts, keywords, reviewers' comments, and other information as necessary
- Linking of documents to relevant sampling or other Site data
- Filing of digital copies of documents for access by the project team

2.9 Summarize Data for RI/FS Analyses and Reporting

Data management activities carried out in support of analytical and reporting activities conducted for the RI/FS include:

- Preparation of a wide variety of data summaries and maps
- Development of data summarization and reporting tools as necessary
- Acquisition and organization of ancillary data (e.g., guideline values, model parameters, and model results) so that they can be efficiently used in conjunction with other data
- Preparation of report tables and figures

2.10 Provide Access to Data

Data management activities carried out to allow respondents and regulators access to the RI/FS data include:

- Provision of tools, training, and support to respondent team members to allow querying of the database
- Setup of a website portal for the sharing of documents and data with regulators
- Upload of the project database to a website portal to allow access by regulators and reviewers
- Assistance to users to facilitate their understanding and use of the data

2.11 Back Up and Maintain Database and Data Files

The project database and all GIS files will be stored on a networked server.

All data on the networked server will be stored on redundant, mirrored hard drives to protect against data loss due to hard drive failure. These drives will be mounted in a file server protected by an uninterruptible power supply. The data from these drives, as well as any other data stored elsewhere on the network, will be backed up daily after work hours to a separate, corporate backup server to protect against data loss due to user error. This backup enables access to the most recently changed versions of all files. Overall, components that make up the data infrastructure (systems that store, backup, archive, etc.) and network systems will be monitored and maintained weekly to ensure that ongoing data storage and access needs are efficiently managed. Backup procedures will protect the data from system failure, accidental damage, catastrophic failures, and intrusion.

3 TYPES OF DATA TO BE MANAGED

The primary types of data to be managed during the RI/FS are:

- Field sampling data, primarily consisting of physical and chemical measurements in a variety of environmental media
- Spatial data that provides supporting and contextual information to assist with the visualization and interpretation of sampling data
- Documents containing information related to sampling data, to current or historical conditions, to standard methods and approaches, to relevant findings from other sites or research studies, and to project status and agreements.

3.1 Field Sampling Data

Field sampling data includes information from field logbooks, field data sheets, GPS devices, field measurement instruments, and analytical laboratories. Field sampling data can be highly complex as a result of factors such as multiple sampling locations, dates, and depths; subsamples, splits, and different levels of sample replication; multiple analytical methods, data quality objectives and actual data quality and precision; and interpretation methods that may require a variety of methods of data summarization, standardization, or transformation. Because of this complexity, management of field sampling data is expected to make up the major part of the overall data management effort for the RI/FS. Appropriate systems and procedures will be used to deal efficiently with this complexity; these are described in later sections of this DMP.

3.2 Spatial Data

Spatial data includes study-specific information such as investigation areas, sampling stations, river and tributary boundaries, facilities, and remediation areas. This information is ordinarily augmented by other spatial information such as topography, road networks, and political boundaries. The basic spatial data may be augmented by the results of spatial or other analyses, such as surfaces computed by data interpolation, and transport pathways produced by numerical models or topographic analyses. Spatial data sets are ordinarily quite different by nature and do not all conform to any standard format. Furthermore, during the course of acquisition and analysis of spatial data, temporary working versions or subsets of the data are often created. Therefore, a major component of data management for spatial data is the documentation and tracking of authoritative versions of spatial data sets.

3.3 Documents

Documentation of the sources of data stored in the database and of other information used to analyze and interpret the data is essential to ensure that the results are valid and supportable. Document management functions therefore must be integrated with the management of other Site data. Documents to be managed in this way include project plans, field records, laboratory records, relevant scientific literature, records of discussions and agreements between the parties, and reports produced during the project.

4 PROJECT DATA FLOW

Data management processes are distinguished in part by the different types of data that they use, transform, or produce. The relationships among these processes, and the flow of data between them, are illustrated in Figure A-1. Many data management processes involve interactions with the project database.

5 DATA MANAGEMENT SYSTEMS

The major data management systems to be used for the RI/FS include:

- A relational database to manage environmental data, track spatial data, and record project documents
- A GIS to organize, manipulate, and use the spatial data
- An internet portal to make the data and documents available to project participants and the public

5.1 Database

A relational database will be used to organize, analyze and store project information and data, and guarantee data integrity. Both current and historical data will be stored in the project database.

Relational databases store data in different types of well defined tables that are linked to each other via common fields. Each table represents a particular class of information, such as the information describing a sampling location, the information describing a sample, or the information describing an analytical result. The links between tables typically represent one-to-many relationships, such as the relationship between a single sampling location and the many samples that might be collected at the location. This linkage enables the efficient storage, updating, and retrieval of data, and the enforcement of data integrity rules. These data integrity rules ensure, for example, that sampling locations and dates are known for all chemistry data entered into the system.

Relational database software will be used specifically to:

- Provide a single authoritative repository for environmental characterization data
- Maintain an inventory of GIS data layers
- Carry out calculations and data summarization
- Execute queries that summarize data completeness, quality assurance status, and final assessments of data quality levels, to support quality assurance assessments
- Store citations of project related documents and link documents to data as appropriate

The set of tables contained in the database (the data model) is designed specifically for management of environmental characterization data of the sort that will be used for this RI/FS. In particular, it accommodates the multiple levels of subsampling, field replication, quality control duplication, laboratory replication, and reanalyses that are typical of environmental chemistry data. The database not only includes document management features, but requires that each analytical result be linked to a specific document, so that the provenance of each data value is established. Laboratory quality control information related to chemical analyses is stored in the database and can be summarized to support data validation. The results of data validation are stored as qualifiers attached to each measured value. In addition to storing the qualifiers themselves, the database stores information on the type of data validation performed and the workflow state (see Section 6) of each data value during the process of data validation. Details of the database structure are presented in Tables A-2 and A-3. The principal database tables containing sampling and analytical chemistry information are shown in Figure A-2. This figure (an entity-relationship diagram) shows the primary keys of each table in boldface. Primary keys ensure that data are not erroneously duplicated in the database. Figure A-2 also shows the relationships between tables, illustrating the one-to-many relationships. For example, there is a one-to-many relationship between study locations and sample collections because multiple collections may be made at each location.

The data model illustrated in Figure A-2 supports multiple levels of subsampling and replication, from multiple studies sampling the same location down to laboratory replicates for analytical chemistry data. At the sampling location level, a single unique identifier is assigned to every location at which a sample is collected. If different identifiers have been assigned to this location by different studies, these multiple identifiers are also stored as study-specific identifiers. These two levels of location information allow data to be easily summarized by location either within a study or across studies.

At the sample level, collections, samples, and splits are distinguished. A sample collection represents material that may be subsampled to produce the actual samples that will be used for data interpretation. A sediment core is an example of a collection: the core is collected as an entirety, but then (typically) subsampled into individual horizons, and analyses collected on the individual horizons. A fish is also (in some cases) an example of a collection: the entire fish is collected, but separate parts of it (e.g., fillet and carcass) may be submitted for analysis. By explicitly modeling the distinction between a collection and a sample, the database allows related samples to be identified, and data to be summarized and compared at either level.

Sample splits (or duplicates) are distinguished from samples themselves because they are a key component of field quality control programs. Data for corresponding splits of the same sample must be interpreted as part of the data validation process. Samples may also be split for the purpose of sending different aliquots to different laboratories for analysis. By explicitly modeling the distinction between a sample and multiple splits of that sample, the system is designed to facilitate the validation of analytical chemistry data.

Because of differences in analytical capabilities, different laboratories may analyze the same sample. In some cases, the same laboratory may analyze a sample more than once. To clearly distinguish these different analysis events, the system maintains a record of the laboratory sample identifiers that are assigned by the analytical laboratory every time a new analysis of a sample is initiated. By explicitly modeling this information, the system maintains a record of the origin of each chemical analysis result. The laboratory sample identifiers also provide a link to laboratory data packages and by recording them, the database therefore supports the validation of analytical chemistry data.

Laboratory analyses are typically replicated at a frequency of 1 in 20 as a quality assessment measure. A laboratory replicate identifier is assigned to every result in the database to allow these replicates to be distinguished. Maintenance of this information in the database helps prevent ambiguity in the data and supports data quality assessments conducted as part of data validation.

Throughout the data model, the database contains a variety of information that describes the data sets and their data quality. This includes data qualifiers, indicators of the level of data validation conducted, workflow state indicators (see Section 6), links to related documents, and narrative comments. Altogether, these features provide users with the information necessary to assess the suitability of data for any particular purpose.

5.2 GIS

Many of the RI/FS activities will use spatial data sets and analyses for planning, data interpretation, decision support, and data presentation. Spatial data will be stored in several different formats, as appropriate for the type of data and its intended use. Sampling station locations will be stored in the project database in a format that allows geographic relationships to be evaluated and used for data selection and summarization. Boundaries that will be used for data selection and summarization (the preliminary Site perimeter, for example) will also be stored in the project database in a format that allows geographic relationships to be evaluated. Spatial data not stored in the project database will be stored in GIS industry standard file formats. Vector data (points, lines, and polygons), will be stored as shapefiles (*.shp), or in personal and file geodatabase feature classes. Raster data such as aerial photos and digital elevation models will be stored as ESRI grid files (*.adf), TIF files (*.tif), or JPEG 2000 file format (*.jp2). The specific file format of the data will depend on the needs of the task.

5.3 Internet Portal

An internet portal will be set up to allow staff of the USEPA and Trustee agencies to download and use the project database. A copy of the project database will be provided on this portal in Microsoft® Access format. This copy of the database will be updated as warranted based on changes to the data. During the period when newly collected sampling data are being validated, updates will occur approximately every 2 weeks, to include the latest validated data.

Access to the portal will be limited to those individuals approved by the USEPA Remedial Project Manager, McGinnes Industrial Maintenance Corporation, and International Paper Company. Users will be required to enter a password when logging in to the portal site, to prevent unauthorized access.

6 DATA MANAGEMENT PROCEDURES

Procedures for handling RI/FS data are described below. These procedures are intended to ensure that the new and existing data that are collected and used for Site characterization and risk assessments are as complete and as accurate as possible. The following descriptions of data management procedures include a discussion of data formats, processes, and tracking of the state of the data.

Data that are acquired for use in the RI/FS undergo a multistep process to merge them with other data in the database. This process ensures that data sets are complete and compatible with other data in the system. The multistep process is referred to as the workflow for a data set. Workflows differ for different kinds of data. In particular, the workflow for data collected as part of prior studies differs from the workflow for laboratory measurements made specifically for this RI/FS.

Workflows can be represented in different ways. For example, a flowchart emphasizes the processes that make up a workflow. However, to answer questions about the status of a data set, it is necessary to have information about the state that each data set (or each data value within a data set) is in. This leads to a representation of the workflow as a state transition diagram rather than as a flowchart. Figure A-3 is a flowchart of the process for entering and checking data acquired from previous investigations. It is annotated with the workflow state of the data, and illustrates the relationship between processes and the corresponding states of the data. Figure A-4 is the corresponding state transition diagram. Workflows for handling specific types of data are described in the following sections.

6.1 Existing Data Sets

Pre-existing data from within the study area will be acquired and loaded into the database as appropriate.[1] These data typically are in a variety of different formats, requiring that they be transformed or entered from spreadsheets, PDF documents, or even hard copy reports. This DMP does not describe detailed procedures for transferring data from all possible formats into the database. These procedures will be carried out by staff with appropriate expertise in

[1] Criteria for identifying appropriate pre-existing data sets, such as chemicals measured and sample collection dates, are identified in the RI/FS Work Plan, not in the DMP.

spreadsheet and database software and who have experience working with the target database format.

The general procedure for entering existing data sets into the project database is to transform the data and load them into staging tables where the data integrity rules of the project database are applied. After these data integrity constraints are satisfied, the data are loaded into the project database. Tabular summaries of the newly entered data are then prepared, and are used to check the data against the original data sources. If discrepancies are found, the data are then corrected and the quality assurance checks repeated. This process is illustrated as a flowchart in Figure A-3 and as a state transition diagram in Figure A-4. After the data have been entered into the database, and throughout the rest of the process, the current workflow state will be recorded for each analytical result.

6.2 Field Sampling Data

During field operations, effective data management is essential to provide consistent, accurate, and defensible documentation of data quality. Field data will include field collected data (e.g., water quality values) and identifying information and descriptive and geographical information associated with air, soil, sediment, groundwater, surface water, and tissue sample collection. Complete and correct recording of field data during sample collection is essential to ensure that the associated analytical results are usable for the RI/FS. The type of information to be collected during field investigations, and formats for data collection, are described in the following section.

6.2.1 Field Records

To avoid alteration, damage, or loss of field data during the RI/FS, it will be the responsibility of the field lead for each task to ensure that at the conclusion of each field event that all original copies of field data (i.e., field logbooks, field data sheets, chain-of-custody [COC] forms) remain in his or her possession until these documents are placed in the project file. The field lead is also responsible for training junior staff in the specifics of documentation and COC requirements (see the Field Sampling Plan [FSP] for each task for additional details). Standardized field records and COC documentation minimizes the chance of loss or damage of project data. This section provides guidance and data requirement checks of field records and defines corrective actions if errors are detected in field records.

Daily field records (a combination of field logbooks, field data sheets, and COC forms) and navigational records will make up the main documentation for field activities. As soon after collection as possible, field logbooks and data sheets will be scanned to create an electronic record for use in creating the investigation report.

Data available only in hard copy (e.g., field logbooks, field data sheets, and COC forms), along with all field measurements, will be hand-entered into the database and reviewed for corrections before use. All hand-entered data will be subjected to 100 percent verification against the source document. Electronic quality assurance checks to identify anomalous values will also be conducted following data entry.

6.2.1.1 Field Logbooks

All field activities and observations will be noted in a field logbook during fieldwork. The descriptions will be clearly written with enough detail so that participants can reconstruct events later if necessary. Field documentation will include only factual descriptions of Site-related activities and observations. Field logbooks will contain any changes in personnel and responsibilities or deviations from the RI/FS Work Plan or the task-specific FSP. Requirements for logbook entries include the following:

- Logbooks will be bound, with consecutively numbered pages.
- Removal of any pages, even if illegible, is prohibited.
- Logbook corrections will be made by drawing a single line through the original entry, allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote in the logbook for explanation.
- Entries will be made legibly with black (or dark) waterproof ink.
- Unbiased, accurate language will be used.
- Each consecutive day's first entry will be begun on a new, blank page.
- The person recording the field information must sign and date the last page at the end of each day, and draw a line through any blank space remaining on the page below

the last entry.

- The date and time, based on a 24-hour clock (e.g., 0900 for 9 a.m. and 2100 for 9 p.m.), will be recorded on each page.
- Entries will be made while activities are in progress or as soon afterward as possible (the date and time that the notation is made will be noted as well as the time of the observation itself).
- When the specific field task is complete, the logbook will be entered into the project file.

In addition to the preceding requirements, the person recording the information will initial and date each page of the field logbook. If more than one individual makes entries on the same page, each recorder will initial and date each entry.

Separate logbooks for each field task will be needed because several field activities may occur at once and multiple field teams could be in field at the same time.

6.2.1.2 Field Data Sheets

Information such as sediment core penetration depths, vane shear test measurements, surface water properties (e.g., temperature) and sampling data (e.g., sampling gear) may be noted on field data sheets. Depending on the activity, the type of field data sheet and the information recorded on it may vary. For instructions regarding the proper field form to use for a specific field task, sampling personnel should consult the task-specific FSP.

A reference date and activity will be entered into the logbook to refer to the field data sheets being generated. The field data sheets will be kept in the project file as a permanent record of the sampling or field measurement activities. If field data sheet entries are entered in an electronic format, each sheet will be annotated to indicate who completed the data entry and when. The field lead is responsible for ensuring that all required information on field data sheets is answered before the field sampling is completed and the information becomes part of the permanent file.

6.2.1.3 Equipment Calibration Records

If field measurements are required for a specific task (e.g., water quality measurements), then equipment calibration records including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration will be recorded in the field logbook.

6.2.1.4 GPS Records

GPS requires no calibration, because all signal propagation is controlled by the U.S. government (the Department of Defense for satellite signals and the U.S. Coast Guard for differential corrections). The accuracy of the GPS requires coordinates to be known for one (or more) horizontal control point and will be verified within the study area. The GPS position reading at any given station will then be compared to the known control point. The GPS accuracy will be verified at the beginning and end of each sampling day.

Upon return from the field, all GPS files will be electronically downloaded for post-processing. The field lead will be responsible for ensuring that all required station location information is collected during the field sampling and the information becomes part of the permanent file. Electronic quality assurance checks to identify anomalous values will also be conducted following data transfer from the field to the project files.

6.2.1.5 Chain of Custody Record

The COC record will ensure that precise documentation of sample possession and handling is maintained from the time of collection until final Site decisions are approved. The COC record will include:

- Sample labels and custody seals
- Sample logbooks and field data sheets
- COC forms
- Laboratory-generated sample logs produced upon receipt of the samples at the laboratory

The COC form is a critical component of the COC record. The field lead will be responsible for completing this form for their specific field task. The COC form will be sent to the laboratory with the samples. At the laboratory, the COC form will be signed when received by the laboratory. The following information will be included on the COC form:

- Site name
- Field lead's name and team members responsible for collection of the listed samples
- Collection date and time of each sample
- Sampling type (e.g., composite, grab, trawl)
- Number of sample containers shipped
- Requested analysis
- Sample preservation information
- Name of the carrier relinquishing the samples to the transporter, noting date and time of transfer and the designated sample custodian at the receiving facility

In cases of project time constraints or analytical concerns, the person responsible for completing the COC form also will note whether samples require rapid laboratory turnaround. These notes will be made in the remarks section of the form. The original COC form will be transported with the samples to the laboratory and will remain in the laboratory's file until the laboratory provides the reviewed and verified analytical data associated with the samples listed on the form. At that time, the original COC forms will be provided with the hard copy of the analytical results; both will be stored together in the project files. The COC form will note all shipping data (e.g., shipper's tracking number, organization, time, and date). A complete custody record will consist of the original and any duplicate COC forms along with the shipper's label or delivery note. The field lead is responsible for ensuring that all COC records are correct and complete.

6.2.2 Workflow

Information will be transferred from field logbooks, field data sheets, and GPS download files into appropriate staging tables for the database. These procedures will be carried out by data management staff who are skilled in the use of spreadsheet, database, and GPS interface software, and who have experience working with the target database format. Data integrity constraints will be applied in the staging tables to ensure that the data are complete and are appropriately structured to be integrated into the project database. The data will then be loaded into the project database and summaries produced and checked against the original field records. If discrepancies are found, they will be corrected and the checks repeated.

The process of loading field sampling information into the database parallels the process used for other existing data. Figures A-3 and A-4 illustrate the workflow from the perspectives of the process and of the data states, respectively.

6.3 Laboratory Deliverables

The laboratory deliverable will include EDDs and data packages in hard copy and PDF formats. EDDs will include sample identification information, analyte concentrations in field and quality control samples, units, and other related information. Data packages will include data summaries with all instrument printouts and raw data needed to complete full validation of the data. For this project, an EDD format will be used that facilitates upload of laboratory results into the project database.

After a laboratory deliverable is received, data management staff will carry out the following procedures to support data validation and ensure that the data are ready to be used for interpretation and analysis:

- EDDs will be loaded into staging tables. Integrity constraints will be applied and quality assurance checks run to ensure that the data are complete and interpretable. Variances from the specified EDD format will be corrected by the data manager, in consultation with the laboratory as appropriate. If necessary, the laboratory will be requested to correct and resubmit the EDD. After these quality assurance checks are completed successfully, data will be moved from staging tables into the database. Default significant digits will be assigned when the data are loaded: 2 digits for organic analytes and 3 digits for other analytes.
- Summaries of field and laboratory quality control data will be produced to support validators' data assessments. A summary of the results for natural samples will also be provided to validators in a spreadsheet format; values, qualifiers, and significant digits will be edited by the validators as appropriate, and the spreadsheet will be returned to the data manager.
- Upon receipt of validation results from the data validators, data managers will update

the database appropriately. The quality assurance level assigned to the data will be updated. Original concentration values reported by the laboratory will be retained in the database, even if the concentrations are restated by the validator.

- The data manager will produce summaries of the data following the update, and will perform (or delegate) an independent verification of these data against the validators notes.
- The data manager will produce tables summarizing field and laboratory quality control data, for inclusion in the data validation report.

The process of loading laboratory results from EDDs into the project database is illustrated in Figure A-5 as a flowchart and in Figure A-6 as a state transition diagram. The current workflow state will be recorded for each analytical result as the data progress through this process.

6.4 Spatial Data

Many of the RI/FS activities will use GIS for decision support, analysis, and display. Spatial data analyses will be carried out, and maps produced, using ESRI ArcGIS software version 9.3.1, or newer version. The spatial database and GIS software use a common spatial reference framework: the Texas State Plane coordinate system, South Central Zone (FIPS 4204). For this coordinate system, the units are U.S. Survey Feet, and the datum is the North American Datum of 1983. All data will be presented and analysis will be performed in this common spatial reference framework coordinate system. Sampling coordinates measured in the field using a GPS will be managed and uploaded to the project data repository following the procedures detailed in the standard operating procedure that accompanies the FSP.

The project database will be used to maintain an inventory of all authoritative spatial data sets. Every spatial data set that is used in a deliverable map or data analysis will be included in the GIS inventory. Each such data set description will include notes regarding any update or revisions mad to the data set. The inventory record for each data set will include the name, originator, coordinate system, and other descriptive information for the spatial data set, including the details and rationale for changes made.

To facilitate use, a common spatial reference system will be applied to spatial data. The following standards will be applied:

- Horizontal Datum: North American Datum of 1983 (NAD83)
- Projection: State Plane Coordinate System, Texas south central
- Units: U.S. feet

All spatial data stored in the database will be stored in this format.

Quality assurance measures will be applied to spatial data collected as part of this study. These measures will include procedures for ensuring that field data are recorded and preserved accurately and verification of check plots with field personnel. Data that have to be re-projected into the project coordinate system will be checked to determine their accuracy. Any limitations on accuracy of a data set will be noted in the GIS inventory.

File-based spatial data sets that are used in project deliverables will be frozen. If subsequent revisions to any such data set are required, a new version with a distinct file name will be created. The status of such data sets (frozen or not) and any superseding data set will be noted in the GIS inventory.

6.5 Data Summarization

Chemistry data will frequently be summarized for use in analyses or for presentation using tables or maps. Summarization will be performed when there are multiple concentration values measured for a sample, or for a specific location, date, and depth. Multiple concentration values result from field or laboratory replications, from field splits created for quality control evaluations, and sometimes from sample reanalyses. Although field splits and laboratory replicates are created to support data quality assessments, all of the valid results that are produced are informative, are stored in the database, and are used to produce the most accurate possible estimate of the true concentration in a sample. When there are replicate results for a sample, the data will be averaged in a step-wise, or hierarchical, fashion. Because each level of the hierarchy represents a different source of variation, all the results at a single level are averaged together before results are averaged across levels. The different levels of replication, and the source of variation that each represents, are as follows:

- Laboratory replicates variability of laboratory measurement methods
- Laboratory re-analyses variability of overall laboratory procedures
- Sample splits variability of field sample handling or homogenization procedures
- Field replicates spatial variability and variability of sample collection procedures

Data will be summarized by successive averaging across these levels of replication, in the order given above. During the averaging process, data validation qualifiers and significant digits will be propagated. The rules for propagating the data validation qualifiers *U* (undetected), *J* (estimated), and *R* (rejected) are as follows:

- If both detected and undetected data are to be averaged, then undetected data lower than the highest detected value will be taken at one-half the detection limit and averaged with the detected data, and the result will be identified as detected.
- If all data to be averaged are undetected, the result will be taken to be the lowest detection limit, and will be identified as undetected.
- If *J*-qualified data are averaged with non-*J*-qualified data, the result will be *J*-qualified.
- If *R*-qualified data are averaged with non-*R*-qualified data, the result will be *R*-qualified.

6.6 Documents

The project database will be used to store citations for all authoritative or finalized documents. The database will be used to record the name, authors, date, and other descriptive information for documents. Every project document will be assigned a unique identifier, and that identifier will be used as a key to the citation in the database. Electronic copies of project documents will be stored as PDF files and the document's file name will be included as part of the document description in the database. Paper copies of project documents will be filed by the document identifier.

7 COMMUNICATION AND DATA SHARING

Data and technical support in the use and interpretation of those data will be provided to regulatory oversight agencies. A copy of the project database will be maintained on the project portal website (see Section 5.3). Data management staff will provide telephone and e-mail support regarding use of the portal and regarding structure and content of the database.

TABLES

Table A-1
RI/FS Activities and Data Management Actions

RI/FS Activity	Corresponding Data Management Actions
Project planning	Implementation of a project database (including security and backup procedures); acquisition, integration, and summarization of existing tabular and geographic data, and document citations, needed for planning; development of the data management plan.
Sample collection, including pre- and post-collection activities	Summarization of data to support identification of sample locations; development of location and sample identifier conventions; preparation of target location information for use by field crews; incorporation of field sampling information into the project database; logging and filing of field records.
Laboratory analyses	Transmittal of electronic data deliverable specifications to the analytical laboratories; acquisition, verification, and integration of analytical results for natural samples and field and laboratory quality control samples into the project database.
Data validation	Preparation of summaries of results for natural samples and quality control summaries for use by the validators; integration of validation results (qualifier assignments) into the database; summarization of data for use in validation reports.
Data interpretation	Selection and summarization of data as needed for analysis and interpretation (in both remedial investigation and feasibility study phases); acquisition and integration of any additional data used to support data analyses; updating of project library with literature cited.
Reporting	Selection and summarization of data for data tables; preparation of data exports as needed.
Project closeout	Archiving of database, GIS, and document files.

Notes
GIS = geographic information system

Table A-2
Database Tables

Table Name	Description
d_collmeas	Measurements made on sample collections
d_document	Supporting documentation
d_fldqcsamp	Field quality control samples
d_fldqcsplit	Field quality control sample splits
d_labpkg	Lab packages for samples
d_labqcsamp	Laboratory quality control samples
d_labresult	Results from laboratory analysis
d_labsample	Laboratory sample identification
d_location	Geographic coordinates of a sample's location
d_sampchar	Sample characteristics
d_sampcoll	Sample collections
d_sampmain	Sample information for all samples
d_sampmeas	Sample measurements
d_sampsplit	Sample split identifications
d_study	Studies that are contained within the database
d_studylocation	Description of a study's location
e_analmethod	Look up table containing analysis method types
e_analtype	Look up table containing types of analyses
e_analyte	Look up table containing analytes
e_chemclass	Look up table containing chemical classifications
e_collscheme	Look up table containing sample collection schemes
e_composite	Look up table containing types of sample composites
e_coordqual	Look up table containing qualifiers for coordinate values
e_doccat	Look up table containing documentation categories
e_doctype	Look up table containing documentation types
e_fieldgear	Look up table containing a list of possible field gear utilized
e_fieldmeasmethod	Look up table containing field data measurement methods
e_fieldprep	Look up table containing sample field preparation methods
e_lab	Look up table containing laboratory names
e_labextract	Look up table containing laboratory sample extraction methods
e_labmethod	Look up table containing laboratory sample analysis methods
e_labprep	Look up table containing laboratory sample preparation methods
e_leachmethod	Look up table containing laboratory sample leach methods
e_measbasis	Look up table containing sample analysis measurement basis
e_qalevel	Look up table containing levels of quality assurance
e_qctype	Look up table containing types of quality controls
e_riverbank	Look up table containing river proximity descriptions
e_sampcharcode	Look up table containing sample character codes
e_sampcharcodetype	Look up table containing sample character code types
e_sampmaterial	Look up table containing types of sample materials
e_sampmeascode	Look up table containing sample measurement types
e_subsamptype	Look up table containing subtypes of samples
e_taxon	Look up table containing taxonomic
e_unit	Look up table containing measurement units

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_collmeas	study_id	x	Text	25	Study identifier	x	d_study
	sampcoll_id	x	Text	25	Sample collection identifier	x	d_sampcoll
	samp_measurement	x	Text	16	Sample measurement	x	e_sampmeascode
	field_meas_method	x	Text	12	Field measurement method	x	e_fieldmeasmethod
	replicate	x	Text	6	Number of replicates produced	x	
	meas_value.value		Double		Measurement value	x	
	units		Text	10	Unit of measurement	x	e_unit
	meas_value.sig_figs		Integer		Significant figures		
	meas_value.std_dev		Double		Standard deviation		
	meas_value.undetected		Boolean		Was the measurement undetected?		
	meas_value.estimated		Boolean		Was the measurement estimated?		
	meas_value.rejected		Boolean		Was the measurement rejected?		
	meas_value.greater_than		Boolean		Was the measurement greater than reporting limit?		
	qa_level		Text	10	Quality assurance level	x	e_qalevel
	reportable		Boolean		Was the measurement reportable?	x	
	principal_doc		Text	12	Document identifier	x	d_document
	validator_flags		Text	8	Validation flags applied to the measurment values		
	comments		Text		General notes and information		
d_document	doc_id	x	Text	12	Document identifier	x	
	pub_year		Integer		Year of publication		
	authors		Text	150	Author(s) of the publication		
	title		Text	250	Title of the publication		
	publisher		Text	150	Publisher of the document		
	pub_date		Date/Time		Date of publication		
	pub_loc		Text	100	Location of publication		
	doc_type		Text	50	Category of documentation		e_doctype
	url		Text	250	Uniform Resource Locator		
	abstract		Text		Abstract text that summarizes the document		
	first_page		Integer		First page number of the document		
	last_page		Integer		Last page number of the document		
	total_pages		Integer		Total number of pages in the document		
	sent_from		Text	150	Person who supplied the document		
	sent_to		Text	150	Person who received the document		
	copyrighted		Boolean		Is the document copyrighted?	x	
	isbn		Text	24	International Standard Book Number		
	issn		Text	9	International Standard Serial Number		
	filename		Text	64	Name of the file containing the document		
	file_loc		Text	128	File network location		
	bates_prefix		Text	8	Bates Technical College document prefix		
	bates_start		Text	10	Bates Technical College document start		
	bates_end		Text	10	Bates Technical College document end		
	int_lib_id		Text	12	Integral library identifier code		
	other_lib_id		Text	12	External library identification code		
	doc_cat		Text	24	Documentation category field - unused		e_doccat
	journal_issue		Text	24	Journal issue		
	doc_version		Text	16	Document version		
	hard_copy		Boolean		Hard copy filed?		
	complete_copy		Boolean		Is the available copy complete?		
	integral_product		Boolean		Is this an Integral product?		
	comments		Text		Comments		
d_fldqcsamp	study_id	x	Text	25	Study identifier	x	d_study
	qcsample_id	x	Text	20	Quality control sample identifier	x	

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_fldqcsamp	qc_type		Text	12	Type of quality control performed	x	e_qctype
	fldqc_group		Text	12	Flield quality control group	x	
	sample_date		Date/Time		Date sample was created		
	srm_id		Text	50	Standard Reference Material identifier code		
	comments		Text		General notes and information		
d_fldqcsplit	study_id	x	Text	25	Study identifier	x	d_study
	fldqc_sno	x	Text	20	Field quality control sample identifier	x	
	qcsample_id		Text	20	Quality control sample identifier	x	d_fldqcsamp
	comments		Text		General notes and information		
d_labpkg	lab	x	Text	10	Laboratory performing the analysis	x	e_lab
	lab_pkg	x	Text	16	Laboratory package identifier code	x	
	anal_type	x	Text	10	Type of analysis performed	x	e_analtype
	anal_begun		Date/Time		Date the analysis started		
	anal_completed		Date/Time		Date the analysis was completed		
	analyst		Text	32	Person performing the analysis		
	edd_format		Text	40	Description of electronic data deliverable received		
	edd_filename		Text	64	Electronic data deliverable file name		
	qalevel_target		Text	10	Level of quality assurance targeted for the data set		e_qalevel
	qalevel_applied		Text	10	Level of quality assurance applied to data set		e_qalevel
	validated_by		Text	32	Person who validated the data set		
	validation_done		Date/Time		Date when the validation was performed		
	defining_doc		Text	12	Document identifier		d_documentation
	comments		Text		General notes and information		

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_labqcsamp	lab	x	Text	10	Laboratory performing the analysis	x	e_lab
	labqc_samp	x	Text	20	Laboratory quality control sample number	x	
	qc_type		Text	12	Type of quality control performed	x	e_qctype
	comments		Text		General notes and information		
d_labresult	lab	x	Text	10	Laboratory performing the analysis	x	e_lab
	lab_pkg	x	Text	16	Laboratory package identifier	x	
	anal_type	x	Text	10	Type of analysis performed	x	e_analtype
	labsample	x	Text	20	Laboratory sample identifier	x	d_labsample
	material_analyzed	x	Text	20	Material of the sample	x	e_sampmaterial
	method_code	x	Text	60	Analyzation method code	x	e_analmethod
	analyte	x	Text	16	Analyte of interest	x	e_analyte
	meas_basis	x	Text	10	Measurement basis	x	e_measbasis
	lab_rep	x	Text	6	Laboratory sample replication number	x	
	meas_value.value		Double		Measured value	x	
	units		Text	10	Units associated with measurement	x	e_unit
	meas_value.sig_figs		Integer		Significant figures		
	meas_value.std_dev		Double		Standard deviation		
	detection_limit		Double		Laboratory process detection limit		
	quantification_limit		Double		Laboratory process quantification limit		
	reporting_limit		Double		Specified reporting limit		
	maximum_limit		Double		Maximum limit for right-censored data		
	original_lab_result		Double		Value originally reported by laboratory		
	lab_conc_qual		Text	1	Laboratory concentration qualifier		
	lab_flags		Text	8	Laboratory validation flags		
	qa_level		Text	10	Level of quality assurance	x	e_qalevel
	meas_value.undetected		Boolean		The sample measurement value was undetected		
	meas_value.estimated		Boolean		The sample measurement value was estimated		
	meas_value.rejected		Boolean		The sample measurement value was rejected		
	meas_value.greater_than		Boolean		The sample measurement value was above reporting limits		
d_labresult	tic		Boolean		Tentatively identified compounds		
	reportable		Boolean		The sample measurement value is reportable		
	principal_doc		Text	12	Document which initiated the sampling		d_document
	comments		Text		General notes and information		
	validator_flags		Text	8	Validation flags applied to the result values		
	lab_qc_batch		Text	16	Laboratory quality control batch number		d_labqcbatch
	lab_cal_batch		Text	30	Laboratory calibration batch number		

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_labsample	lab	x	Text	10	Laboratory performing the analysis	x	e_lab
	labsample	x	Text	20	Laboratory sample identifier	x	d_labsample
	study_id		Text	25	Study identifier		d_study
	sample_no		Text	20	Sample number		d_sampmain
	bioaccum_sno		Text	20	Biological accumulation sample identifier		d_bioaccumsamp
	fldqc_sno		Text	20	Field quality control sample identifier		d_flldqcsplit
	labqc_samp		Text	20	Laboratory quality control sample number		d_labqcsamp
	treated_sample		Text	20	Sample identifier for treated samples		
	receipt_date		Date/Time		Sample receipt date		
	coc_id		Text	12	Chain of custody form identifier		d_coc
d_location	location_id	x	Text	60	Location identifier	x	
	description		Text	150	Description of the location		
	loc_type		Text	15	Location type		e_loctype
	defining_doc		Text	12	Supporting documentation about the location	x	d_document
	loc_geom		Geometry		Location geometry		
	elevation		Single		Distance above mean sea level		
	elev_unit		Text	10	Units associated with elevation measurement		e_unit
	huc		Text	10	Hydrologic unit code		
	river_mile		Single		Associated river mile		
	river_bank		Text	8	General location description compared to the river bank		e_riverbank
	coord_sys		Text	30	Coordinate system		
	coord_qual		Text	10	Qualifier code for location coordinates		e_coordqual
	comments		Text		Comments		
d_sampchar	study_id	x	Text	25	Study identifier	x	d_study
	sampcoll_id	x	Text	20	Sample collection identifier	x	d_sampcoll
	sampchar_type	x	Text	12	Sample characteristic type	x	e_sampcharcode
	sampchar	x	Text	16	Sample characteristic	x	
	comments		Text		General notes and information		
d_sampcoll	study_id	x	Text	25	Study identifier	x	d_study
	sampcoll_id	x	Text	20	Sample collection identifier	x	
	study_loc_id		Text	60	Study location identifier	x	d_studylocation
	sample_date		Date/Time		Date sample was collected		
	sample_material		Text	20	Material of the sample	x	e_samplematerial
	study_element		Text	16	Study element		
	composite_type		Text	16	Type description of the composite	x	e_composite
	composite_period		Single		The time, area, or distance over which the composite was collected		
	composite_period_units		Text	8	Unit measure for composite period		e_unit
	composite_start_date		Date/Time		Starting time for compositing		
	composite_count		Integer		Number of subcomposites collected to make up the composite sample		
	samp_loc_points		Geometry		Sample geographic location		
	fldqc_group		Text	12	Field quality control group		
	srm_id		Text	32	Standard Reference Material name or identifier		
	coll_gear		Text	12	Sample collection gear utilized		e_fieldgear
	coll_sop		Text	12	Sample collection standard operating procedures		d_document
	coll_scheme		Text	10	Sample collection scheme		e_collscheme
	taxon_code		Text	16	Taxonomic category code		e_taxon
	coll_upper_depth		Single		Sample collection upper depth		
	coll_lower_depth		Single		Sample collection lower depth		
	coll_depth_units		Text	10	Sample collection depth units		e_unit
	coll_success		Text	10	Collection success		
	water_depth		Single		Sample collection depth for water		
	water_depth_units		Text	10	Sample collection depth for water units		e_unit

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_sampmain	flood_stage		Text	10	Description of water level when sample was collected		
	water_gauge		Single		Water level gauge value		
	water_gauge_units		Text	10	Water level gauge value units		e_unit
	weather		Text	10	Weather at the time the sample was collected		
	tide_stage		Text	10	Tide variation stage when sample was collected		
	tide_height		Single		Tide height when sample collected		
	tide_height_units		Text	10	Tide height units when sample collected		e_unit
	sampler		Text	32	Person performing the sampling		
	comments		Text		General notes and information		
	study_id	x	Text	25	Study identifier	x	d_study
	sampcoll_id		Text	20	Sample collection identifier	x	d_sampcoll
	sample_id	x	Text	20	Sample identifier	x	
	subsamp_type		Text	10	Type of subsample	x	e_subsamptype
	sample_material		Text	20	Material of the sample	x	e_samplematerial
	description		Text	255	Description of the sample		
	sample_treatment		Text	20	Treatment applied to the sample		e_samptreat
	original_id		Text	32	Identifier assigned by the original investigator if different from the sample_id		
	defining_doc		Text	12	Document identifier		d_document
	fieldqc_batch		Text	12	Field quality control batch		
	upper_depth		Single		Upper sampling depth		
	lower_depth		Single		Lower sampling depth		
	depth_units		Text	10	Unit measure of depth		e_unit
	taxon		Text	16	Taxonomic category		e_taxon
	field_prep_method		Text	10	Field preparation method		e_fieldprep

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
d_sampmeas	study_id	x	Text	25	Study identifier	x	d_study
	sample_id	x	Text	25	Sample identifier	x	d_sampmain
	samp_measurement	x	Text	16	Sample measurement	x	e_sampmeascode
	field_meas_method	x	Text	12	Field measurement method	x	e_fieldmeasmethod
	replicate	x	Text	6	Number of replicates produced	x	
	meas_value.value		Double		Measurement value	x	
	units		Text	10	Unit of measurement	x	e_unit
	meas_value.sig_figs		Integer		Significant figures		
	meas_value.std_dev		Double		Standard deviation		
	meas_value.undetected		Boolean		Was the measurement undetected?		
	meas_value.estimated		Boolean		Was the measurement estimated?		
	meas_value.rejected		Boolean		Was the measurement rejected?		
	meas_value.greater_than		Boolean		Was the measurement greater than reporting limit?		
	qa_level		Text	10	Quality assurance level	x	e_qalevel
	reportable		Boolean		Was the measurement reportable?	x	
	principal_doc		Text	12	Document identifier	x	d_document
	validator_flags		Text	8	Validation flags applied to the measurment values		
	comments		Text		General notes and information		
d_sampsplit	study_id	x	Text	25	Study identifier	x	d_study
	sample_no	x	Text	20	Sample number	x	
	sample_id		Text	20	Sample identifier	x	d_sampmain
	bottle_count		Integer		Number of containers filled		
	comments		Text		General notes and information		
d_study	study_id	x	Text	25	Study identifier	x	
	full_name		Text	125	Complete name of the study		
	sponsor		Text	80	Sponsor of the study		
	contact		Text	80	Contact person regarding the study		
	primary_doc		Text	12	Document identifier		d_document
	qa_level		Text	10	Target quality assurance level		e_qalevel
	qa_doc		Text	12	Document identifier for quality assurance report for the study		
	source_qa_level		Text	10	Quality assurance level assigned by the original data source		e_qalevel
	comments		Text		General notes and information		
	qa_comments		Text		Notes about data quality assessments		
	primary_doc		Text	12	Document identifier		d_document
d_studylocation	study_id	x	Text	25	Study identifier	x	d_study
	study_loc_id	x	Text	60	Study location identifier	x	
	location_id		Text	60	Location identifier		d_location
	description		Text		Description of the location		
	reference_loc		Boolean		Is there a reference for this location		
	defining_doc		Text	12	Document identifier of document that defines the location	x	d_document
	loc_method		Text	8	Method by which the location geometry was identified	x	e_locmethod
	comments		Text		General notes and information		
	site		Text	40	Identifier for a particular area of concern		
	elevation		Single		Distance above mean sea level		
	elev_unit		Text	10	Units associated with elevation measurement		e_unit
e_analmethod	method_code	x	Text	15	Analyzation method code	x	
	description		Text		Description of the analyzation method	x	
	lab_leach_method		Text	10	Laboratory leach method		e_leachmethod
	lab_prep_method		Text	10	Laboratory preparation method		e_labprep
	lab_extraction_method		Text	10	Laboratory extraction method		e_labextract
	lab_anal_method		Text	10	Laboratory analysis method		e_labmethod
e_analtype	anal_type	x	Text	10	Analysis type code	x	

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
	description		Text		Description of analysis	x	
e_analyte	analyte	x	Text	16	Analyte of interest code	x	
	full_name		Text	120	Full name of the analyte	x	
	chem_class		Text	10	Chemical classification		e_chemclass
	aliases		Text		Other names for the analyte		
	cas_rn		Text	32	CAS number		
e_chemclass	chem_class	x	Text	10	Chemical classification code	x	
	description		Text		Chemical classification description		
e_collscheme	coll_scheme	x	Text	10	Sample collection scheme code	x	
	description		Text		Sample collection scheme description	x	
e_composite	composite_type	x	Text	16	Composite type code	x	
	description		Text		Composite type description		
e_coordqual	coord_qual	x	Text	10	Coordinate system qualifier code	x	
	description		Text	150	Coordinate system qualifier description	x	
e_doccat	doc_cat	x	Text	24	Document category code	x	
	description		Text		Document category description	x	
e_doctype	doc_type	x	Text	50	Document type code	x	
	description		Text		Document type description		
e_fieldgear	gear	x	Text	12	Field gear code	x	
	description		Text		Field gear description	x	
e_fieldmeasmethod	field_meas_method	x	Text	12	Field measurement method code	x	
	description		Text		Field measurement method description		
e_fieldprep	field_prep_method	x	Text	10	Field preparation method code	x	
	description		Text		Field preparation method description	x	

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
e_lab	lab	x	Text	10	Laboratory code	x	
	lab_name		Text		Full name of the laboratory	x	
	street		Text		Street address		
	city		Text		City		
	state		Text		State		
	province		Text	20	Province		
	country		Text	12	Country		
	postal_code		Text	10	Postal code		
	contact		Text		Contact person		
e_labextract	lab_extraction_method	x	Text	10	Laboratory extraction method code	x	
	description		Text		Laboratory extraction method description	x	
e_labmethod	lab_anal_method	x	Text	10	Laboratory analysis method code	x	
	description		Text		Laboratory analysis method description	x	
e_labprep	lab_prep_method	x	Text	10	Laboratory preparation method code	x	
	description		Text		Laboratory preparation method description	x	
e_leachmethod	lab_leach_method	x	Text	10	Laboratory leach method code	x	
	description		Text		Laboratory leach method description	x	
e_measbasis	meas_basis	x	Text	10	Measurement basis code	x	
	description		Text		Measurement basis description	x	
e_qalevel	qa_level	x	Text	10	Quality assurance level code	x	
	description		Text		Quality assurance level description	x	
e_qctype	qc_type	x	Text	12	Quality control code	x	
	description		Text		Quality control description	x	
e_riverbank	river_bank	x	Text	8	River bank location code	x	
	description		Text		River bank location description	x	
e_sampcharcode	sampchar_type	x	Text	12	Sample characteristic type code	x	e_sampcharcodetype
	sampchar		Text	16	Sample characteristic	x	
	description		Text		Sample characteristic description	x	
e_sampcharcodetype	sampchar_type	x	Text	12	Sample characteristic code type code	x	
	description		Text		Sample characteristic code type description	x	
e_sampmaterial	sample_material	x	Text	20	Sample material code	x	
	description		Text		Sample material description	x	
	matrix		Text	1	Sample material matrix	x	e_material
e_sampmeascode	samp_measurement	x	Text	16	Sample measurement code	x	
	description		Text		Sample measurement description	x	
e_subsamptype	subsamp_type	x	Text	10	Subsample type	x	
	description		Text		Subsample description		
e_taxon	taxon_code	x	Text	16	Taxonomic category code	x	
	kingdom		Text		Kingdom		
	phylum		Text		Phylum		
	tax_class		Text		Class		
	subclass		Text		Subclass		
	superorder		Text		Superorder		
	tax_order		Text		Order		
	suborder		Text		Suborder		
	superfamily		Text		Super family		
	family		Text		Family		
	subfamily		Text		Subfamily		
	genus		Text		Genus		
	species		Text		Species		
	subspecies		Text		Subspecies		
	common_name		Text		Common name		

Table A-3
Database Table Descriptions

Table Name	Column	Primary Key?	Data Type	Length Limit	Description	Required?	Valid Values
e_unit	unit	x	Text	10	Unit code	x	
	description		Text		Unit description		
	dimension		Text	5	Unit measurement dimension	x	e_dimension
	as_html		Text	24	The displayable representation, as HTML		
	addend1		Single		Field used to convert units of measure	x	
	factor		Single		Unit conversion factor	x	
	addend2		Single		Field used to convert units of measure	x	
	display		Text	10	The displayable representation	x	

Notes

CAS = Chemical Abstracts Service

FIGURES

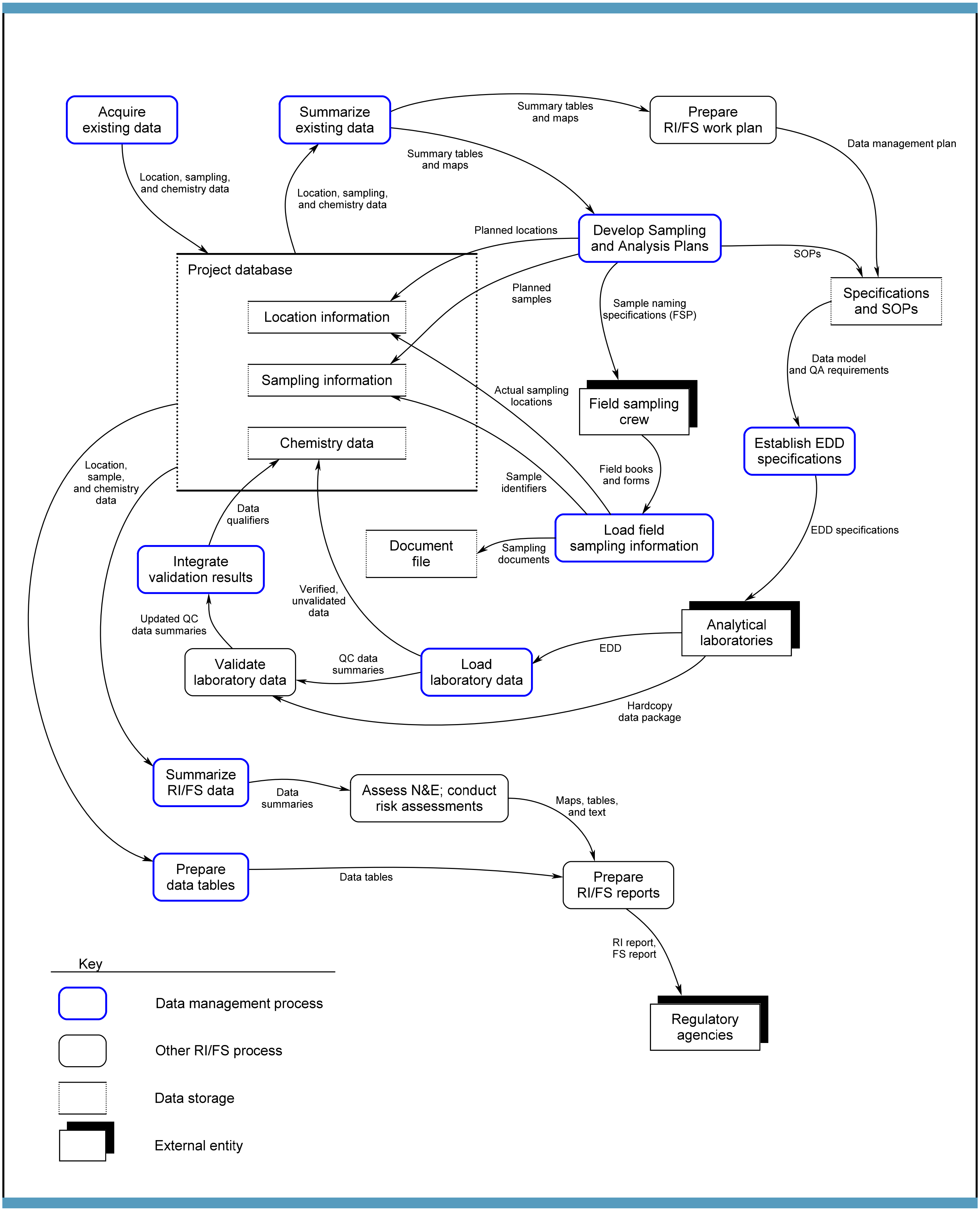


Figure A-1
Data Flow Diagram for Sampling Information
to be Collected during the RI/FS
SJRWP Data Management Plan
SJRWP Superfund/MIMC and IPC

DRAFT

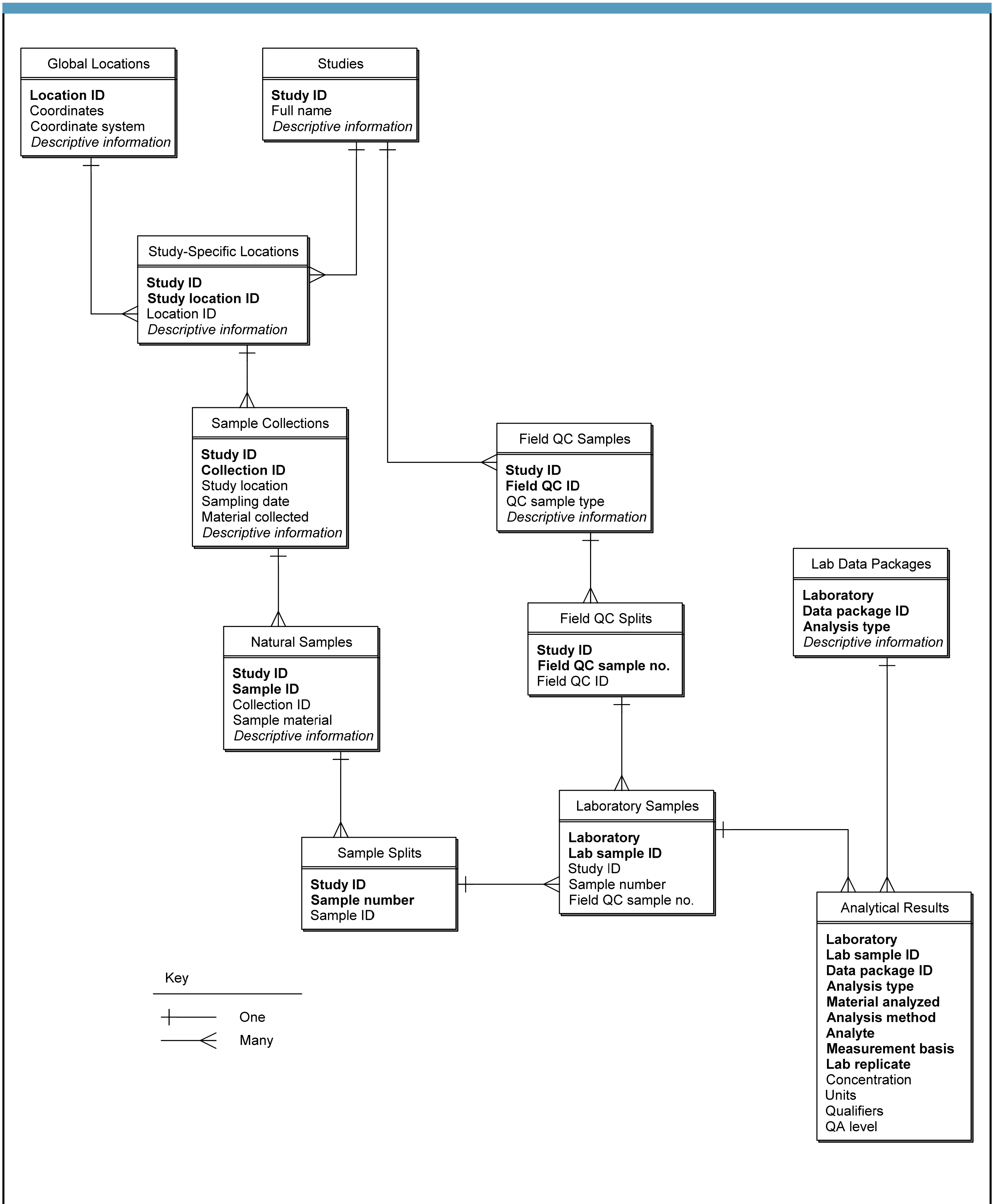
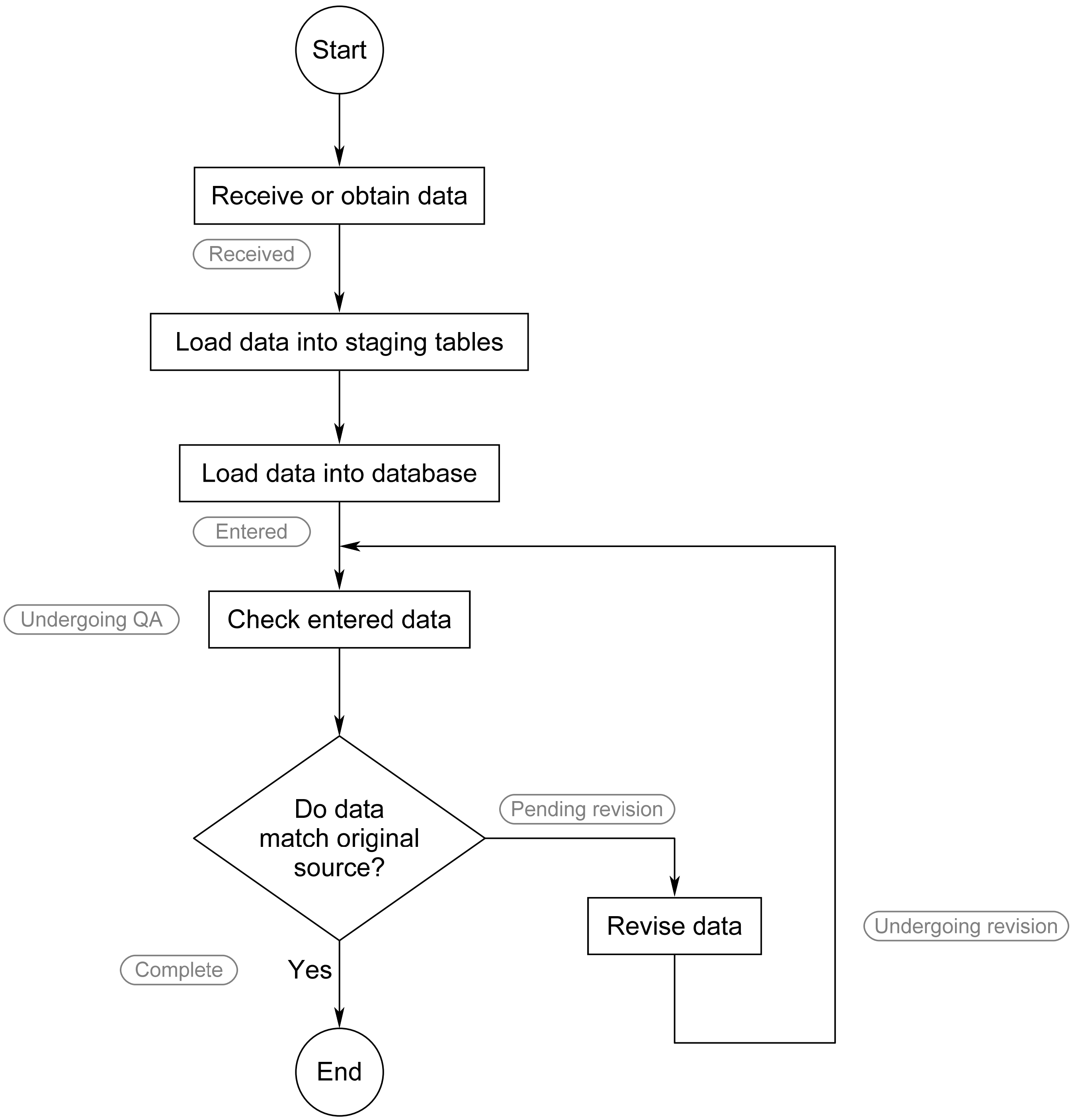


Figure A-2
Database Structure (Entity Relationship Diagram) for Tables Used for Field Sampling Data and Analytical Results


Start
Receive or obtain data
Received
Load data into staging tables
Load data into database
Entered
Undergoing QA
Check entered data
Do data match original source?
Pending revision
Revise data
Undergoing revision
Complete
Yes
End

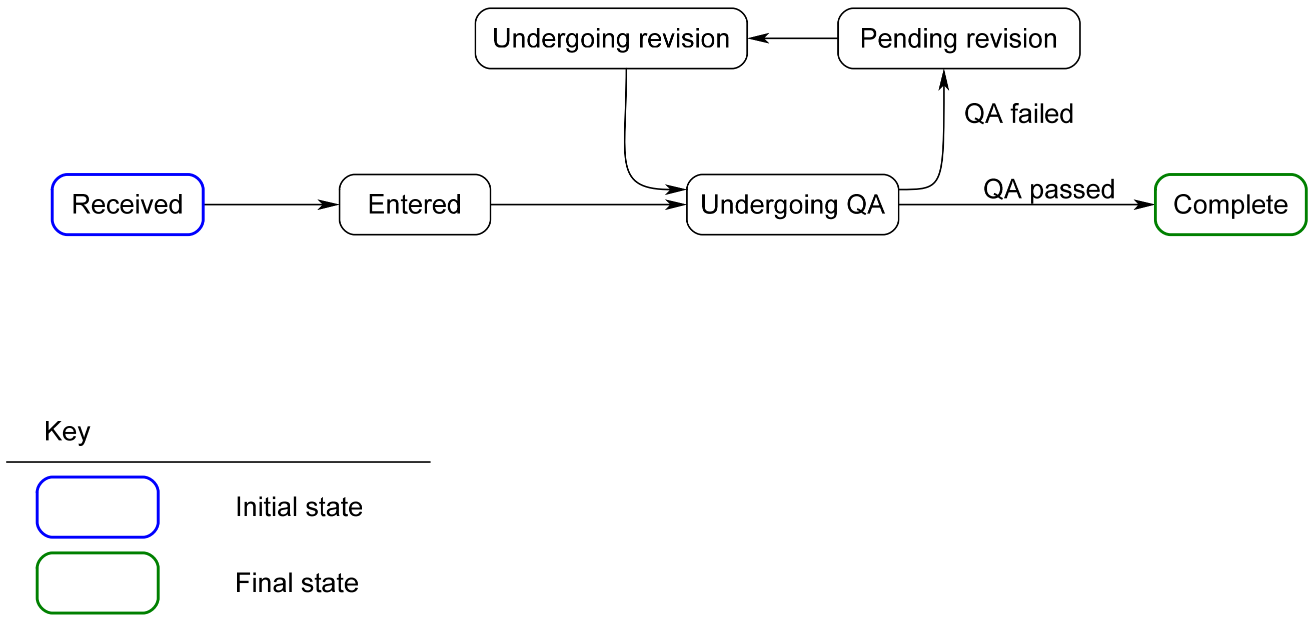


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Figure A-4
Workflow State Transition Diagram for Entry of Existing Data and Sampling Information
SJRWP Data Management Plan
SJRWP Superfund/MIMC and IPC

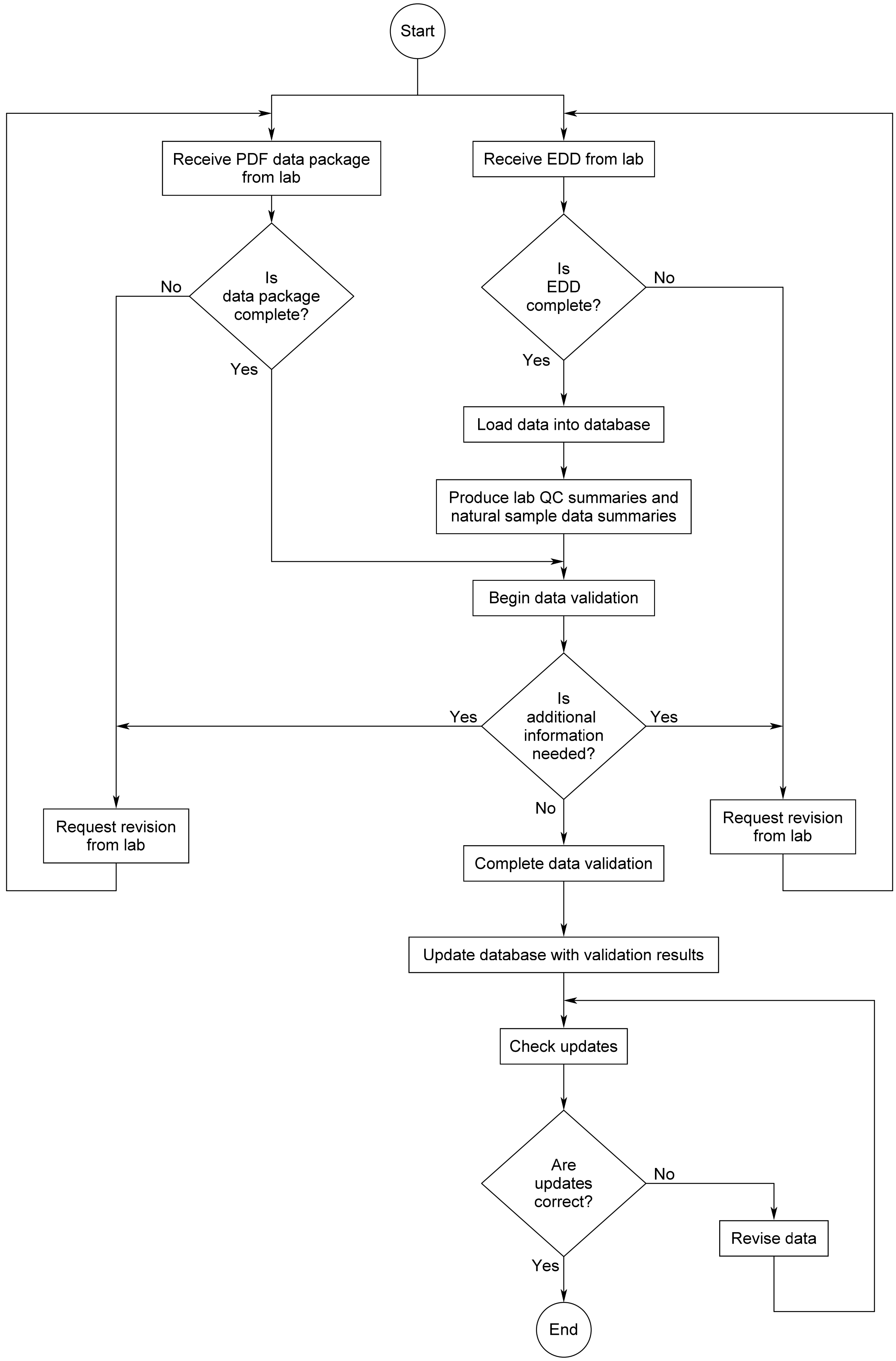

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Figure A-5
Workflow Flowchart for Validation of Analytical Results
SJRWP Data Management Plan
SJRWP Superfund/MIMC and IPC

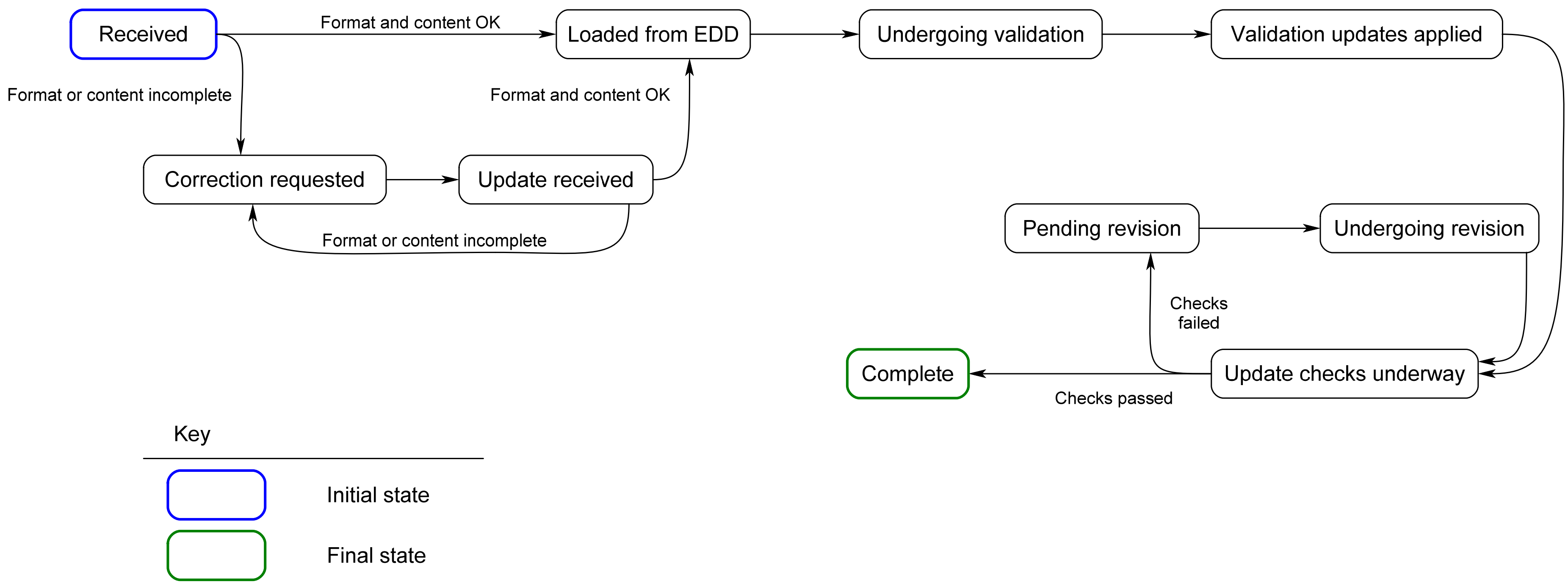

Figure A-6
Workflow State Transition Diagram for Validation of Analytical Results
SJRWP Data Management Plan
SJRWP Superfund/MIMC and IPC

DRAFT

APPENDIX B
REVISED SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

REVISED
SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation
International Paper Company
U.S. Environmental Protection Agency, Region 6

Prepared by

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Seattle, Washington 98104

July 2010

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
BAF	bioaccumulation factors
BERA	baseline ecological risk assessment
COI	chemical of interest
COPC	chemical of potential concern
CSM	conceptual site model
ERA	ecological risk assessment
I-10	Interstate Highway 10
IPC	International Paper Company
K_{ow}	octanol-water partition coefficient
MIMC	McGinnes Industrial Maintenance Corporation
ppt	parts per thousand
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits Site
SLERA	screening level ecological risk assessment
SLV	screening level value
SMDP	scientific management decision point
TCDD	tetrachlorodibenzo-*p*-dioxin
TOC	total organic carbon
UAO	Unilateral Administrative Order
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This Screening Level Ecological Risk Assessment (SLERA) report for the San Jacinto River Waste Pits Site (the Site) has been prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC), pursuant to the requirements of Unilateral Administrative Order (UAO), Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009, (USEPA 2009). This SLERA report has been prepared consistent with USEPA guidance for ecological risk assessments (ERAs) and addresses Step 1 and Step 2 of the 8-step ERA process for Superfund (USEPA 1997) (Figure B-1). As such, this SLERA provides the screening level problem formulation and ecological effects evaluation (Step 1) and the screening level exposure assessment and risk evaluation (Step 2). These evaluations will support development of the problem formulation for the baseline ecological risk assessment (BERA). The approach and methods for completing ERA Steps 3 through 8 are addressed in the Remedial Investigation and Feasibility Study (RI/FS) Work Plan.

Several components of the SLERA are addressed only briefly in this document because they are described in greater detail elsewhere:

- Site history and facilities used at the Site (Section 2 of the RI/FS Work Plan)
- Identification of chemicals of interest (COIs) (Appendix C to the RI/FS Work Plan)
- Identification of chemicals of potential concern (COPCs) (Appendix C to the RI/FS Work Plan)

This SLERA is intended to provide a detailed description of the environmental setting of the Site, and to clearly document the scientific management decision points (SMDPs) to transition from a general understanding of the Site to the more site-specific study design elements and analyses required by the BERA. The SLERA is organized as follows:

- **Section 2**. Screening Level Problem Formulation. This section reviews the available information for the Site that is relevant to the ERA resulting in a general conceptual site model (CSM).
- **Section 3**. Screening Level Exposure Estimate and Risk Calculation. This section provides detailed information to describe the basis for the screening level values

(SLVs) used in the risk-based screens that are described in Appendix C to the RI/FS Work Plan, as noted above.

- **Section 4**. Uncertainty Analysis. Uncertainties in the analyses are addressed.

2 SCREENING LEVEL PROBLEM FORMULATION

The screening level problem formulation uses existing information to develop a preliminary CSM that addresses the following (USEPA 1997):

- The environmental setting and contaminants known or suspected to occur at the Site
- Mechanisms of contaminant fate and transfer that might exist at the Site
- Mechanisms of toxicity and likely categories of receptors that could be affected
- The complete exposure pathways linking contaminants to ecological receptors
- Endpoints that can be used to screen for potential ecological risk

This section summarizes basic information on the environmental setting, chemical fate and transport mechanisms relevant to developing the CSM, receptors potentially at the Site, and the surrogates to be used for risk assessment, and it defines the assessment endpoints for the screening level analysis. A detailed discussion of the toxicity of dioxins and furans is provided in Attachment B2. The resulting CSM synthesizes preliminary information on each of these topics to identify mechanisms of exposure and effects that may result in contaminant-related risks to ecological receptors. The CSM will be refined in the problem formulation presented in the BERA to better reflect site-specific exposures and risks.

2.1 Environmental Setting

The Site consists of a set of impoundments approximately 14 acres in size and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The set of impoundments is located on the western bank of the lower San Jacinto River, in Harris County, Texas, immediately north of Interstate Highway 10 (I-10). The Site is located in a low gradient tidal estuary near the confluence of the San Jacinto River and the Houston Ship Channel (Figure B-2). The primary industrial activity of interest to the RI for the Site occurred in 1965 and 1966 and consisted of the construction of a set of impoundments within the estuarine marsh and the deposition of pulp and paper wastes (both solid and liquid) transported by barge from the Champion Paper Inc., mill in Pasadena, Texas, into these impoundments. The two primary impoundments were divided by a central berm running lengthwise (north to south) through the middle and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm, into the impoundment located to the east of the central berm (Figure B–2). The Site history is described in detail in Section 2.1 of the RI/FS Work Plan.

Available chemistry data for water, sediment, and tissue (Table B-1) and information on the physical setting of the Site were used to prepare this SLERA and the RI/FS Work Plan. A full discussion of the analysis of existing data for the Site is provided in Section 2.3 of the RI/FS Work Plan. This section of the SLERA outlines the physical environment and land uses near the Site, the suspected contaminants and their fate and transport, and the habitats at the Site.

2.1.1 Watershed and Land Use

The San Jacinto River drains an area of 10,160 km^2 and supplies approximately 28 percent of the fresh water entering Galveston Bay (Gardiner et al. 2008). The mainstem of the San Jacinto River downstream from the San Jacinto Dam on the southern rim of Lake Houston in northeastern Harris County flows southeast for 28 miles to its mouth on Galveston Bay, east of Houston. Lake Houston, which is 9 miles long, and the river below it are formed by the confluence of the 69-mile-long East Fork and the 90-mile-long West Fork of the San Jacinto River. The San Jacinto Dam is an earthfill dam that is 62 feet high with a concrete spillway. The reservoir that is created by the dam is used for recreation, as well as an industrial, municipal, and agricultural water supply.

The construction of the Houston Ship Channel in 1914 resulted in a deepening and widening of the lower San Jacinto River to link the Port of Houston with Galveston Bay and the Gulf of Mexico, although the dredging did not extend as far upstream as the impoundments. It is likely that construction of the Houston Ship Channel directly altered surface water circulation of Galveston Bay by providing a larger cross-section for north to south water movement on the main axis of the bay and by breaching Redfish Bar, which had previously limited water exchange between the upper and lower bay (Lester and Gonzalez 2005).

The Site is located in a mixed residential and commercial area; areas to the north and east are either undeveloped or residential, and areas to the west and south of the Site are residential, commercial, and industrial (Figure B-3), including two constructed reservoirs: Lynchburg Reservoir to the southeast and Lost Lake on the Island in the center of the San Jacinto River west of Lynchburg Reservoir (Figure B-4). The area of the impoundments is not directly subject to vehicle traffic or human activity other than fishing and recreation. The terrestrial portions north of I-10 are used illegally by trespassers for recreational fishing and swimming. South of I-10, terrestrial and shoreline portions of the Site are used for ship repair and other industrial activities. The shoreline to the north of I-10 includes areas of uniformly sandy beaches, while elsewhere the shoreline is a mix of sand, vegetation, riprap, and other debris. Shallow estuarine waters abut the shoreline, and deeper estuarine waters offshore are maintained for shipping activities.

2.1.2 Habitats

The Site is located in a hydrologically dynamic tidal section of the San Jacinto River. To the west of the central berm, the impounded area is currently occupied by late successional stage vegetation, and to the east, the historically impounded area is consistently submerged even at low tide. Habitats in the northern portion of the Site include shallow and deep estuarine waters, and shoreline areas occupied by estuarine riparian vegetation and human developments. Upland terrestrial areas to the west of the impoundments, where sand sorting took place as sediments were processed after dredging, are denuded and covered with crushed cement and sand (Figure B-2). The perimeter of the graded industrial upland area above high tide is populated by estuarine riparian vegetation. The sandy shoreline of this area is littered with riprap, other metal debris, and piles of cement fragments. Estuarine riparian vegetation also lines the upland area that runs parallel to I-10. A sandy intertidal zone is present along the shoreline throughout much of the Site.

The San Jacinto River in the vicinity of the Site is characterized by low salinity waters (1 to 5 parts per thousand [ppt]; Clark et al. 1999). The in-water portion of the Site is characterized as primarily non-vegetated, with deep (7 to 10 m central channel) and shallow (1 m or less) areas (NOAA 1995; Clark et al. 1999). The riverbed in the vicinity of the Site is characterized by sediments with a relatively low organic content (0.2 to 3 percent; University of Houston and Parsons 2006) and moderate sand content (22 to 42 percent; ENSR and EHA 1995).

The tidal portions of the San Jacinto River and Galveston Bay provide rearing, spawning, and adult habitat for marine and estuarine fish and invertebrate species including blue crab (*Callinectes sapidus*), black drum (*Pagonius cromis)*, southern flounder (*Paralichthys lethostigma*), spotted sea trout (*Cynoscion nebulosus*), and grass shrimp (*Palaemonetes pugio)* (Gardiner et al. 2008; Usenko et al. 2009). Detailed lists of plant and animal species potentially occurring at the Site are discussed in Section 2.3. An estimated 34 acres[1] of estuarine and marine wetlands are found within the preliminary Site perimeter (USEPA 2009). From the San Jacinto Dam to the confluence of the San Jacinto River with the Houston Ship Channel there are approximately 55 acres of freshwater, estuarine, and marine wetlands (Figure B-4).

The shoreline of the San Jacinto River consists of a mix of natural habitats and industrialized areas with development up to the river's edge (Figures B-3 and B-4). Upland natural habitat adjacent to the San Jacinto River is generally low-lying, displaying little change in elevation, and consists primarily of clay and sand that supports loblolly pine-sweetgum, loblolly pine-shortleaf pine, water oak-elm, pecan-elm, and willow oak-blackgum woods along the river's banks (TSHA 2009).

2.1.3 Contaminants Known or Suspected to Occur at the Site

To identify chemicals known or suspected to occur at the Site, information characterizing the types of waste materials generated by bleached kraft pulp mills in the 1960s and the chemistry of these types of wastes was compiled, and existing data for chemistry of seven sediment samples collected from within the impoundments in 2005 by TCEQ and USEPA (2006) were reviewed. Chemicals that were on the priority pollutant list and were detected at least once in Site sediments were considered to be COIs. Chemicals that were never detected or were never analyzed in Site sediments were considered to be COIs if they met the following criteria:

- The chemical is a priority pollutant
- The chemical may be expected to occur in bleached kraft pulp mill solid or liquid wastes generated in the 1960s

[1] Acreage of wetlands for the Site and study area was estimated from wetland polygons on the habitat map (Figure B-5).

- The chemical is persistent in the environment

The list of COIs that meet these criteria is provided in Table B-2. Each of these COIs was then individually evaluated using risk-based screens for wildlife and benthic macroinvertebrates to identify COPCs for ecological receptors. This evaluation is presented in detail in the Sediment Sampling and Analysis Plan (SAP) (Integral and Anchor 2010), and is also provided as Appendix C to the RI/FS Work Plan. Application of the risk-based screens and identification of COPCs is summarized in Section 3.

2.2 Contaminant Fate and Transport

The characterization of contaminant fate and transport includes identification of: 1) pathways for migration of contaminants at the Site; and 2) physical, chemical, and biological transformations of these contaminants. Understanding fate and transport helps define the exposure pathways leading to ecological receptors that may be adversely affected by Site contaminants (USEPA 1998). This section discusses the current understanding of chemical transport and transformation pathways at the Site. The RI/FS Work Plan provides more detailed discussion, and identifies data gaps that will be addressed in future evaluations that are planned for the RI/FS. A Technical Memorandum on Chemical Fate and Transport will be provided according to the schedule in Section 8 of the RI/FS Work Plan.

2.2.1 Physical Fate and Transport Processes

Physical changes at the Site in the 1970s and 1980s, including the subsidence of land in the area due to large-scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments and exposure of the contents of the impoundments to surface waters. Based upon review of U.S. Corps of Engineers (USACE) approved dredging permits (e.g., Permit Nos. 11357 and 19284 issued to Houston International Terminal, Inc.), aerial photo interpretation, recent bathymetric survey results, and an evaluation of the distribution of dioxin in surface sediments surrounding the Site, it appears sand mining-related dredging by third parties has occurred in the vicinity of the perimeter berm at the northwest corner of the impoundments. Recent data from sediment samples collected nearby to the north and west of the impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than national background levels (USEPA 2000).

2.2.2 Biological Fate and Transport Processes: Bioaccumulation

Bioaccumulation is relevant to the ERA for several chemicals. A simple definition of bioaccumulation is the sequestration of a chemical substance in an organism when the absorption rate (from exposures to all media) exceeds the elimination or transformation rates, resulting in the concentration in tissue exceeding the concentration in the exposure medium. Bioaccumulation of chemicals only through contact with water is referred to as "bioconcentration." Bioaccumulation dynamics and rates are specific to the substance of concern, the exposure route, the medium or media in which the chemical is delivered, and the type of organism. Biomagnification is related to bioaccumulation and describes the increase in the concentration of a substance with increasing trophic level in a food chain (e.g., from primary to tertiary consumer). Biomagnification appears to be restricted to a relatively small group of chemicals (Croteau et al. 2005; Suedel et al. 1994).

A key indicator of the potential for bioaccumulation is the chemical's hydrophobicity, which is most often expressed using the *n*-octanol-water partition coefficient, K_{ow}, and can be used to predict bioaccumulation potential. Hydrophobic and lipophilic organic compounds that are resistant to both degradation and excretion in organisms build up in adipose tissue. Generally, organic chemicals that significantly bioaccumulate are those that are non-ionic, have a log K_{ow} of 5 or greater, and are not rapidly metabolized or excreted (USEPA 2008a). The bioaccumulation of dioxins and furans is still not well understood. A review by USEPA (1992) suggests that fish accumulate tetrachlorinated, but not more highly chlorinated, dioxin and furan congeners. More recent literature indicates that dioxin and furan congeners that are not tetrachlorinated at the 2, 3, 7, and 8 positions have very limited bioaccumulation potential in vertebrates (USEPA 2008b).

Metals bioaccumulation is complex, and bioaccumulation rates can vary with the concentration in the exposure medium. As a result, simple models of metals bioaccumulation, such as the use of bioaccumulation factors, are often inappropriate for metals (USEPA 2007). Moreover, many aquatic species have evolved in metals-rich environments and have physiological means to isolate metals in their tissues or biochemical mechanisms to render metals non-toxic. As a result, tissue concentrations are not generally a reliable means to predict metals toxicity in aquatic species (USEPA 2007).

Bioaccumulation is considered a relevant process for determining the fate of COIs at the Site, and chemical-specific bioaccumulation potential is incorporated into the risk-based screens that are applied in Appendix C (to the RI/FS Work Plan) to identify COPCs for ecological (and human) receptors. A Technical Memorandum on Bioaccumulation will be submitted according to the schedule in Section 8 of the RI/FS Work Plan, and will describe the bioaccumulation processes of interest to the RI and the BERA, and the means to address them for this Site.

2.2.3 Additional Data Needs for Fate and Transport

Additional data and analyses are needed to characterize the hydrodynamics and transport processes that govern the fate of chemicals at the Site. Additional data and information needs include: 1) chemical loads from the San Jacinto River (e.g., upstream sources); 2) chemical loads from atmospheric deposition; 3) volatilization rates; 4) adsorption-desorption kinetics (i.e., partition coefficients for particle-associated chemicals); 5) porewater concentrations; 6) total organic carbon (TOC) data for sediments; and 7) tissue concentrations of COPCs, and 8) Site-specific relationships between tissue chemistry and environmental parameters, if any. Site-specific studies described in the RI/FS Work Plan will provide empirical data on chemical contamination of biological tissues, and will explore the potential for development of one or more models to predict tissue chemistry from chemical concentrations in abiotic media. Estimates of the surface water concentrations of some chemicals, and the variability of surface water chemistry over time, is also required to understand both physical fate of contaminants and accumulation in biological tissue. These data gaps and the approaches for obtaining empirical data or model results to address these data gaps are more fully described in the RI/FS Work Plan and associated SAPs for the Site.

2.3 Selection of Surrogate Ecological Receptors

This section and Attachment B1 describe the potential ecological receptors at the Site, identify the criteria used for selection of surrogate or representative species for each receptor group, and identify surrogate species to be evaluated in the BERA and the rationale for their selection. A surrogate receptor species is chosen to represent a group of related species with similar feeding patterns, habitat associations, or other life history characteristics that affect the exposure potential of the receptor group. To identify receptor surrogates, an overview of broad categories of ecological receptors that are expected to use the Site is included, and surrogate receptor species for evaluation in the BERA are proposed. Finally, this section addresses those species considered to be threatened or endangered and discusses the approach for evaluation of risk to these species.

2.3.1 Selected Receptor Surrogates

Ecological receptor surrogates are considered representative of the trophic and ecological relationships known or expected at the Site. In selecting receptor surrogates for evaluation in the BERA for the Site, the following criteria were considered:

- The receptor is or could potentially be present at the Site.
- The receptor is representative of one or more feeding guilds.
- The receptor is known to be either sensitive or potentially highly exposed to COPCs at the Site.
- Life history information is available in the literature or is available for a similar species that can be used to inform life history parameters for the receptor.

Many species of aquatic-dependent wildlife may nest in, forage in, and/or migrate through the lower San Jacinto River system. Detailed tables listing the species of plants, benthic invertebrates, reptiles, fish, birds, and mammals that could use the habitats on the Site or in the vicinity of the Site are provided in Attachment B1.

Given that sediments, upland soils, and surface water are the primary environmental media determining the fate and transport of Site-related chemicals, the choice of receptors focused on aquatic-dependent species, or those species which use aquatic resources to a substantial extent. Fish and aquatic-dependent wildlife species for which there are potentially complete exposure pathways to Site-related chemicals include those with direct contact with contaminated soil, sediment, and water and those that prey on benthic macroinvertebrates or on fish that consume benthic macroinvertebrates. Few amphibians that are potentially present in the region are tolerant of brackish or saline waters, with the possible exception of the southern leopard frog (Attachment B1). Amphibians are therefore not likely to be in contact with contaminants at the Site, are probably not an ecologically important component of the ecosystem expected at the Site, and are not considered relevant to the BERA.

Terrestrial species are also represented by avian and mammalian surrogate receptors that use upland habitats. The receptors discussed below are summarized in Table B-3.

2.3.1.1 Benthic Macroinvertebrate Community

Benthic macroinvertebrates spend most of their life cycles living in or on the sediment, often in highly localized areas, and are potential prey to many fish and aquatic-dependent wildlife species and therefore contribute to a complete exposure pathway linking higher trophic level organisms to Site-related COIs. Benthic macroinvertebrates known to occur in the vicinity of the Site include crabs, shrimp, oysters, and clams (Broach 2010; GBIC 2010) (see also Attachment B1); blue crabs have also been collected from the river channel adjacent to the impoundments (University of Houston and Parsons 2006). In addition, smaller species adapted to the low salinity conditions, such as euryhaline polychaetes, oligochaetes, and amphipods, are also expected to be in the vicinity of the Site.

Relatively sessile invertebrates (e.g., clams) may have a higher exposure potential to COIs in sediments at the Site than more mobile invertebrates (e.g., crabs and shrimp). For the BERA, the benthic macroinvertebrate community will be a receptor. In addition, due to their relatively high sensitivity to dioxins and furans (Attachment B2), mollusks will be a surrogate receptor that will be evaluated in the BERA.

2.3.1.2 Fish

The fish community at the Site includes a variety of euryhaline species with various feeding strategies, including omnivores, invertivores, and piscivores. Fish species observed in association with or collected from the tidal portion of the lower San Jacinto River include hardhead catfish (*Ariopsis felis*), blue catfish (*Ictalurus furcatus*), black drum (*Pagonius cromis)*, southern flounder (*Paralichthys lethostigma*), and spotted seatrout (*Cynoscion nebulosus*) (Osborn et al. 1992; University of Houston and Parsons 2006; Gardiner et al.

2008). The three surrogate receptors highlighted below incorporate several life history characteristics important to measuring exposure to bioaccumulative contaminants, including long lifespans, limited home ranges (a focus on non-migratory species), proximity to and feeding from sediments, and mid- and upper-trophic level diets.

Gulf killifish (Fundulus grandis)

The Gulf killifish is a relatively small (up to 18 cm), omnivorous species common in estuaries and rivers of the Gulf Coast. They are euryhaline, capable of living in fresh or salt waters. Their prey include grass shrimp (*Palaemonetes*), microcrustaceans (copepods), mosquito (*Dipteran*) larvae and pupae, bivalve mollusks, other small fishes, and aquatic plants and algae (Hassan-Williams et al. 2010). Gulf killifish are non-migratory and are likely a permanent resident at the Site. The Gulf killifish is commercially important as a baitfish and as prey for larger fish.

Black drum (Pogonias cromis)

Black drum is a large-bodied estuarine invertivore common in the bays and estuaries of the Gulf of Mexico. Studies in Texas have shown substantive intrabay movement, but not movement among embayments (Osborn et al. 1992). Tagging studies have recorded migrations of 245 miles in 1 year or less, but most distances covered were less than 10 miles (TPWD 2009). The black drum's diet consists of mollusks, crabs, and shrimp (TPWD 2009). Black drum found within the Site are likely to be part of the local resident population. They are likely to be present at the Site throughout the entire year and use the immediate area for food and shelter. The black drum is an important fish for the commercial and recreational fishing industries.

Southern flounder (Paralichthys lethostigma)

Southern flounder is a large piscivorous flatfish common in the Gulf of Mexico. It is euryhaline and tends to be found in tidal muddy flats at the upper reaches of estuaries. As an adult, the southern flounder is almost strictly piscivorous, but will opportunistically feed on large invertebrates (i.e., crabs and shrimp) (Osborn et al. 1992). It is a migratory fish that moves out to the open Gulf in the winter to spawn. During early spring, southern flounder move into estuaries, where they stay for the remainder of the year. Aside from seasonal migrations, this species tends to have limited movement from its chosen home range. Based on the presence of habitat at the Site that matches this species profile, it is likely that this species can be found in the Site vicinity for much of the year except during the winter spawning period. The southern flounder is an important fish in terms of commercial and recreational fishing and is a highly prized food fish. In addition, the high trophic position of this species presents the potential for bioaccumulative effects. Its highly sediment-associated lifestyle increases the likelihood of exposure to lipophilic chemicals such as dioxins.

2.3.1.3 Reptiles

Reptiles that may be expected at the Site include snakes and turtles (Attachment B1). Ecotoxicity data for reptiles is limited compared to other wildlife taxa. A single omnivorous species for which life history information is available in the literature was chosen as a surrogate receptor for reptiles.

Alligator snapping turtle (Macrochelys temminckii)

This species inhabits larger rivers, swamps, and bayous and is found in the upper Galveston Bay ecosystem (Attachment B1). It is omnivorous, consuming aquatic vegetation, aquatic and terrestrial invertebrates, and small fish and amphibians. A study of an Oklahoma population of alligator snapping turtle found that adults have an average linear home range of about 800 m and juveniles an average linear home range of about 1,000 m (UMMZ 2010). They are listed as a threatened species in the state of Texas (Attachment B1).

2.3.1.4 Birds

Both aquatic-dependent and terrestrial bird species are expected to be present at the Site and are potentially exposed to contaminants. The following sections discuss the kinds of birds that are expected to live and forage in the vicinity of the Site. A summary of the aquatic-dependent and terrestrial bird species likely to be found in the vicinity of the Site, as well as a more comprehensive listing of both aquatic and terrestrial bird species recorded near the Site at the Baytown Nature Center, is presented in Attachment B1.

2.3.1.4.1 Aquatic-Dependent Birds

Raptors, herons, rails, pelicans, gulls, ducks, and sandpipers use the aquatic habitat that is present in the vicinity of the Site. Dabbling ducks, including gadwall and teal, may winter in the vicinity of the Site. Sandpipers, egrets, and herons are wading birds that forage along shallow intertidal areas for benthic macroinvertebrates and small fish. Piscivorous bird species that may forage in the open waters of the river include cormorants, osprey, and pelicans. Omnivores including gulls and ducks may forage at the river's edge as well as in the water column. Surrogate aquatic avian receptors were chosen to be representative of the feeding guilds likely to be present in the vicinity of the Site and that have the potential for complete exposure pathways to contaminated media.

The surrogate receptors described below represent the dietary habits and habitat uses that result in potentially complete exposure pathways linking birds to sediment-associated chemicals at the Site.

Neotropic cormorant (Phalacrocorax brasilianus)

Neotropic cormorants are year-round residents in coastal Texas. Although opportunistic at times, neotropical cormorants feed predominantly on fish smaller than 8 cm (Telfair and Morrison 2005). They are tolerant of a range of climatic and environmental conditions and inhabit wetlands in fresh, brackish, or salt water. Key habitat requirements include water deep enough for diving and elevated perches in trees, shrubs, or other structures for nesting, roosting, and drying plumage after feeding. Neotropic cormorants forage mainly by pursuit-diving and are the only cormorant known to plunge-dive in shallow waters (less than 2 m depth) (Telfair and Morrison 2005). Foraging area for this species is present at the Site, and the species is likely to roost nearby. Behavioral and physiological characteristics of this species are fairly well documented and this species would be considered protective of larger fish-eating birds (i.e., bald eagles, ospreys, and double-crested cormorants).

Great blue heron (Ardea herodias)

These piscivorous wading birds are opportunistic species that feed primarily on fish and aquatic invertebrates, but will often include terrestrial prey items (e.g., frogs, small mammals) if available (USEPA 1993). Members of this guild primarily stalk or stand and wait for prey by wading into shallow water along marshes and streams. Other heron species that may occur in the vicinity of the Site include great egret, cattle egret, black-crowned night heron, snowy egret, little blue heron, green heron, and tricolor heron (Attachment B1).

Spotted sandpiper (Actitis macularius)

The spotted sandpiper is a shorebird that obtains much of its diet by probing or "mining" soft sediments along shorelines (USEPA 1993). Spotted sandpipers are relatively common winter residents in some of the local habitats around the Houston Ship Channel (Attachment B1) and their foraging habitats are present at the Site. This species is a generalist feeder and will occupy almost all habitats near water. Spotted sandpipers are visual foragers and prey on all manner of aquatic and terrestrial invertebrates and occasionally small fish. Although several other shorebirds may typically obtain a greater fraction of their diets from aquatic sediments, the spotted sandpiper was selected as a representative of its feeding guild primarily because:

- Their relatively low body weight and higher metabolic rate result in relatively high ingestion rates for this feeding guild.
- Their life history, behavior, and physiological characteristics are well documented (USEPA 1993).

Because of the high potential exposure and their direct ingestion of sediment, the spotted sandpiper is representative of both omnivorous birds and benthivorous sediment probing birds.

2.3.1.4.2 Terrestrial Birds

A number of predominantly terrestrial bird species, such as doves/pigeons, killdeer, crows, and many smaller passerines (e.g., swallows, mockingbirds, wrens, sparrows) likely occur in the upland portions of the Site. To identify an appropriate surrogate terrestrial avian receptor for the Site, the size of available upland habitat within the Site perimeter, the expectation of the receptor to be found at the Site, the presence of exposure pathways linking receptors to contaminated soils, and bioconcentration information were considered.

Predatory birds such as harriers and the red-tailed hawk have been observed in the vicinity of the Site. However, raptor species are expected to have large foraging ranges relative to the amount of natural terrestrial habitat available within the Site. The average foraging area for a red-tailed hawk population in other states ranges from 1,700 to 4,400 acres (USEPA 1993); the area of undeveloped or lightly disturbed upland within the perimeter of the Site is estimated at only 117 acres. In addition, information provided in support of USEPA guidance for risk assessments at combustion facilities (USEPA 1999) suggests that predatory receptors such as raptors may not be as highly exposed to dioxins and furans as other receptors that have closer contact with soils. Specifically, USEPA (1999) estimated bioaccumulation factors (BAFs) for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) from soils and plants to avian receptors. They estimated BAFs of less than 1 for raptors (4.78×10^{-1} for American kestrel) and for their mammalian prey (7.81×10^{-5} as the BAF from soil for deer mouse and 1.7×10^{-4} for marsh rice rat) (USEPA 1999). These small BAFs indicate that low rates of bioaccumulation of 2,3,7,8-TCDD via soil/sediment and mammalian prey limits potential exposure to birds of prey at the Site.

However, soil-to-receptor and plant-to-receptor BAFs greater than 1 have been estimated for robin (USEPA 1999), an omnivorous bird that feeds on plants and terrestrial invertebrates. Therefore, a bird species that is likely to be present on the Site and that has: 1) an invertivorous ground-feeding strategy; and 2) a higher Site fidelity/smaller home range is the killdeer (*Charadrius vociferous*), and this species was selected for use as a surrogate avian terrestrial receptor.

Killdeer (Charadrius vociferous)

The killdeer is an upland plover that feeds predominantly on terrestrial invertebrates (e.g., earthworms, beetles, grasshoppers, and other small invertebrates). Stomach contents from killdeer in Texas were reported to contain 98 percent animal matter, mostly worms and insects (McAtee and Beal 1924). The species is widespread in open areas (e.g., agricultural fields, lawns, golf courses) throughout North America and is non-migratory across the southern United States, including Texas (Jackson and Jackson 2000). It is known to be common year-round in the vicinity of the Site (Attachment B1). This species is remarkably tolerant of constructed disturbances, and nesting has been documented from construction sites, road shoulders, and graveled rooftops (Jackson and Jackson 2000). Average nesting home ranges of killdeers in Minnesota were relatively small (0.57 acres). Larger, year-round home ranges of approximately 15 acres are reported elsewhere; nesting period home ranges were smaller. Nesting in Mississippi occurs from mid-March through late July and involves multiple broods (Jackson and Jackson 2000). Due to its likely presence in the upland portions of Site, its relatively small home range and site fidelity, and its predominantly terrestrial invertebrate diet, the killdeer is representative of the species that would be subject to ecological risks associated with the terrestrial food chain at the Site. The use of this surrogate species would be considered protective of smaller home range bird species at the Site (e.g., sparrows, wrens) that likely eat a larger percentage of plant matter, as well as larger omnivores (e.g., crows), and would also be protective of terrestrial ecosystem-based carnivores (e.g., hawks) that likely have larger home and forage ranges.

2.3.1.5 Mammals

The number of mammalian species that feed on aquatic prey and that may occur within the Site is limited to six aquatic-dependent mammals: raccoons (*Procyon lotor*), muskrats (*Ondatra zybethicus*), nutria (*Myocastor coypus*), Virginia opossum (*Didelphis virginiana*), river otters (*Lutra canadensis*), and marsh rice rats (*Oryzomys palustris*). Marsh rice rats, nutria, and muskrat may be expected in the vicinity in wetland areas with emergent vegetation and river otter may use or move through the area while foraging for prey. Opossum, marsh rice rat, and raccoon may use riparian and terrestrial areas adjacent to the river for foraging and corridors for moving across territories (Attachment B1). Skunks may also be present in the area, as evidenced by tracks that were observed in intertidal sands during a Site visit on December 10, 2009, but they do not live in close association with the aquatic environment.

Although mink may be present in other parts of the Galveston Bay system, the type of habitat at the Site is not considered appropriate for mink and therefore mink were not considered an appropriate mammalian receptor for the Site. Mink prefer wetland habitats with abundant cover such as shrubby or dense vegetation and well developed riparian zones, prefer small streams to large broad rivers, and avoid exposed or open areas of the type that characterize the shorelines of the Site (Allen 1984). In addition, mink have not been found to be highly sensitive to dioxin-like compounds (Attachment B2).

Raccoon, muskrat, nutria, and marsh rice rat are all abundant species in coastal Texas and suitable habitat for these species is present at the Site, although the muskrat prefers tall aquatic grasses (i.e., tall sedges and bullrush) for nesting, and these are limited in abundance at the Site. Nutria and muskrat only rarely include animal prey in their diets and instead live primarily on aquatic and semi-aquatic vegetation. Raccoon and marsh rice rat are both highly opportunistic and vary their diet based on the availability of prey and organic material. Both species would be expected to use areas throughout the Site. Because the physiology and behavior of raccoon are better understood, the raccoon was selected as a surrogate receptor for mammals that use both terrestrial and aquatic habitats. The marsh rice rat was also selected as a surrogate receptor species for mammals that use both terrestrial and aquatic habitats because it is likely present, it is a smaller mammal than the raccoon and may therefore have a higher ingestion rate, and it has a varied, omnivorous diet.

Raccoon (Procyon lotor)
Raccoons are omnivorous and use both riparian and terrestrial upland habitats for foraging. The ecology, physiology, and behavior of raccoons are well understood, and exposure parameters are readily available in the literature for this species (USEPA 1993). The selection of this species is considered protective of other semi-aquatic omnivorous mammals due to its equal or higher proportion of animal matter in its diet, thereby increasing the probability of exposure through biomagnification relative to other omnivorous or herbivorous mammals.

Marsh Rice Rat (*Oryzomys palustris*)
Habitats of the marsh rice rat range from coastal salt marshes to freshwater springs in mountainous areas. The marsh rice rat prefers habitats occupied by sedges and grasses, which provide cover for the marsh rice rat to avoid predators. Nests are built of sedges and may be placed under debris, in shrubbery, or in shallow burrows. This mammal eats both vegetable and animal matter; animal prey includes insects, juvenile birds and bird eggs, fish, clams, crustaceans, and snails (Wolfe 1982).

2.3.2 Threatened and Endangered Species

Attachment B1 provides lists of species that could occur at the Site. Among the animals listed in Attachment B1, the ones that are state-listed as threatened or endangered are:

- Timber rattlesnake
- Smooth green snake
- Alligator snapping turtle
- White-faced ibis
- Brown pelican

- Rafinesque's big-eared bat

In addition to these listed species, the American bald eagle, protected under the federal Bald and Golden Eagle Protection Act and listed as threatened by the State of Texas may be found in the vicinity of the Site.

The two snakes that are listed are unlikely to occur on the Site. Available information on habitat choices for these snakes indicates that they prefer upland forested habitats, prairies, and fields or mesic habitats with good vegetative cover. They are not considered common occupants of estuarine or marine wetlands. The alligator snapping turtle has been selected as the surrogate receptor for reptiles.

The white faced ibis prefers freshwater wetlands, but can be found in estuarine habitats. It is intermediate to the surrogate receptors sandpiper and great blue heron in terms of both body size and diet. It is omnivorous and apparently opportunistic, consuming aquatic insects, fish, amphibians, and crustaceans. The extent to which this bird would use the Site is unknown, but it has been observed at the nearby Baytown nature center (Appendix B1, Table B-7).

The brown pelican is a marine piscivore that preys on small surface-schooling fishes, similar to the feeding strategy of the neotropic cormorant. The American bald eagle may hunt for fish, or eat carrion found on terrestrial and shoreline areas. Both of these species are expected to have foraging ranges different from those of the species selected as bird receptor surrogates for the BERA.

The Rafinesque's big-eared bat is not expected to use the habitats found in the vicinity of the Site because it feeds primarily on emergent aquatic insects, which are generally restricted to freshwater systems and are uncommon in brackish estuarine waters.

In light of this information, the white-faced ibis, brown pelican, and American bald eagle are the protected species with a reasonable likelihood of occurring and possibly foraging on the Site. The risk assessment for these species will not employ the use of surrogates to represent their exposure potential, because the use of surrogates is intentionally conservative, and could result in an overestimate of risk to these listed species. Instead, realistic exposure parameters (e.g., to describe controlling variables such as the feeding rate, area use rate, and composition of the diet) will be identified for these species using the literature, and species-specific exposures will be evaluated against the appropriate toxicity reference values in the BERA.

2.4 Potential Routes of Exposure

For an exposure pathway to be complete, a contaminant must be able to travel from its source to an ecological receptor, and to be taken up by the receptor by one or more exposure routes. Complete exposure pathways for fish, invertebrates, and aquatic-dependent wildlife result from ingestion of contaminated water, soil, or sediments; ingestion of prey organisms that have been exposed to contaminated media and have bioaccumulated COIs; direct contact with contaminated water, soil, or sediments; and respiration. Interpretation of the significance of each exposure route in any species is dependent upon the availability of information in the literature. This section describes in general terms the routes of exposure of ecological receptors to chemicals at the Site and indicates how each is addressed in this SLERA.

2.4.1 Ingestion

Direct ingestion of chemicals is commonly used to evaluate exposure in an ERA because much of the available and relevant toxicity literature for birds, mammals, and fish reports on the oral toxicity of chemicals and because many receptors ingest multiple contaminated media (i.e., food, water, soil, and sediments), so the oral dose is greatest among the possible exposure routes for many species. Invertebrates, fish, and reptiles ingest soil and sediment directly while burrowing or foraging. Birds and mammals can ingest soil and sediment directly while foraging and cleaning their fur or feathers (Beyer et al. 1994).

Animals also ingest bioaccumulative COIs through consumption of contaminated prey tissue. The extent to which trophic transfer via ingestion occurs is dependent on numerous factors, including the exposure of the prey to COIs, the bioaccumulation potential of the specific chemical, the extent to which the chemical is partitioned in the tissues of the prey, and what parts of the prey are eaten by the receptor. Trophic transfer is of particular importance for hydrophobic bioaccumulative chemicals of concern and for higher trophic-level consumers (e.g., raptors and carnivorous mammals).

Given the salinity of the surface water in the San Jacinto River in the vicinity of the Site, it is not expected that surface waters within the Site will provide the primary source of drinking water to mammals. Marine birds and marine reptiles rely on seawater for hydration, using salt glands in the anterior skull to release excess sodium chloride from ingested water. Ingestion of water is relevant to the BERA for these receptors, but is not considered by the SLERA because the fraction of the dose of each chemical via water ingestion, relative to the dose fractions from food and sediment ingestion, is expected to be very low for the COIs at this Site.

The SLERA considers ingestion of COIs through prey by including bioaccumulation potential of each COI in the selection of COPCs (Appendix C to the RI/FS Work Plan). Ingestion of a COI solely through sediment is not considered by the screening evaluation. This approach assumes that if a COI is bioaccumulative, it will be higher in foods than in sediment and therefore must be considered in the BERA, and that if it is not bioaccumulative and does not exceed ambient levels, it is not of concern. The full screening approach is described in Appendix C to the RI/FS Work Plan.

2.4.2 Direct Contact

For ecological receptors, direct contact exposure may include uptake across the integument, and in some cases, such as plankton or algae, across a cell membrane. The extent of direct contact with the exposure medium depends on the chemical and the physiology, habitat, and life history characteristics of the ecological receptor. Although direct contact exposure via transfer across external tissues is possible in ecological receptors, it is rarely quantified directly in ERAs because data are not available in the literature to interpret the toxicity resulting from direct contact uptake in ecological receptors for most chemicals. Instead, more general means of evaluating exposure-response relationships are used. For example, in a bioassay in which the exposure is to water, a test organism may be exposed via dermal uptake, gill uptake, and ingestion of the contaminated water. However, only the concentration in the water is measured and this concentration is used to evaluate the threshold “exposure” associated with effects. Exposures via each route are never quantified or reported, and may not be needed to interpret the results. Due to a fundamental lack of information to differentiate uptake exposures from other routes in exposures of ecological receptors, and to interpret this specific exposure route, absorption across the integument is not explicitly addressed by this SLERA, and will not be explicitly addressed for any receptor by the BERA.

2.4.3 Respiration

Respiration is the exchange of gases between an organism and its environment. Ecological receptors respire through both gaseous and liquid media. Respiration by birds, mammals, and reptiles is facilitated by the inhalation of air, and respiration by all other receptors of interest to this SLERA occurs through an exchange with water using gills or related organs. Although both types of respiration can result in exposure and uptake of chemicals, the inhalation route is not considered by the SLERA. Exposure to COPCs via respiration in a contaminated sediment environment is considered indirectly in the SLERA, and respiration exposures to both contaminated water and sediment will be considered by the BERA.

Although inhalation is a potentially complete exposure route for terrestrial receptors, this route is not generally considered to contribute substantially to exposure risk for ecological receptors, with the possible exception of exposure of volatile compounds to burrowing mammals that may be exposed to vapors in burrows at some sites (USEPA 2003a). Moreover, vaporous materials are not expected to occur on the Site because of the age of the wastes comprising the source of interest to the RI (Appendix C to the RI/FS Work Plan).

Respiration of COIs by aquatic macroinvertebrates is considered implicitly through the use of conservative sediment screening values. The toxicity literature for benthic invertebrates most commonly reports exposures as concentrations in bulk sediments and does not differentiate components of the total dose or toxicity resulting from the aqueous component (the respired dose), direct contact (the dose absorbed across the integument), and the dose due to sediment ingestion. The use of a bulk sediment concentration provides the means to evaluate the exposure-response relationship without addressing each route individually. This approach has been employed in the SLERA, thereby indirectly addressing the respiration route. Respiration by fish is not considered by the SLERA because water quality data are not available, but this route is complete and potentially significant for fish and will be addressed by the BERA.

2.5 Assessment Endpoints

An assessment endpoint is "an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes" (USEPA 2003b). Clearly defined assessment endpoints help structure an ERA to address management decisions. Clarity in assessment endpoints is essential to their role in refining the direction of the risk assessment, and in communicating the meaning of the results generated by the SLERA.

USEPA guidance stipulates that assessment endpoints for a SLERA reflect a conservative evaluation of risk, and address any adverse effect potentially resulting from complete exposure pathways linking contaminants to receptors (USEPA 1998). Consistent with USEPA guidance for the SLERA, assessment endpoints are the populations of chosen receptors as inferred from measures related to survival, growth, and reproduction (USEPA 1998).

The SLERA does not specify the extent or severity of effects of exposure to chemicals on the assessment endpoints for each receptor. Instead, the SLERA identifies those chemicals that have no potential effect on ecological receptors. By using a conservative evaluation of exposure and toxicity, the SLERA identifies those chemicals that require additional evaluation in the BERA, when more realistic and site-specific exposure and toxicity information is considered.

2.6 Preliminary Conceptual Site Model

Figure B-5 presents the overall preliminary ecological CSM for the Site, which describes the sources, transport pathways, and routes of exposure for each of the broad categories of ecological receptors. Figure B-6 provides more detailed information on receptor feeding guilds and their exposure pathways. Two major physical changes resulted in the exposure of the wastes deposited within the impoundments to surface waters and the distribution of contaminated materials into nearby surface sediments: 1) land subsidence resulting from groundwater withdrawal in the 1970s contributed to the sinking of the impoundments; and 2) dredging activities occurred in the vicinity of the perimeter berm surrounding the northwest portion of the impoundments. Mobilization of materials by dredging may also have released sediment-associated contaminants to the water column that would have eventually settled to the bottom.

Contact with and ingestion of contaminated media within the boundary of the impoundment itself, and in other areas to which COIs may have been transported, creates the potential for exposure to ecological receptors using the Site. Contaminants in the near-surface, biologically active and/or physically mixed zone may move between solid and aqueous phases and be remobilized from the sediment bed by sediment resuspension and porewater/surface water exchange. Once in the water column, upstream or downstream contaminant transport can occur. Direct biological uptake can also occur from surface and suspended sediments, porewater and surface water. Ecological receptors using the Site also may be exposed to contamination from global, regional, and local sources of contamination that are unrelated to the Site. Quantification of exposures to Site-related, upstream, and regional sources of contamination, and resulting risks, will be addressed by the RI/FS (Sections 4 and 5 of the RI/FS Work Plan).

Chemicals associated with the waste impoundments are expected to be exclusively those associated with solid wastes produced by bleached kraft pulp mill operations or those that have been detected in sediments collected from within the impoundments (Appendix C to the RI/FS Work Plan).

3 SCREENING LEVEL EXPOSURE ESTIMATE AND RISK EVALUATION

The screening level exposure estimate and risk calculation is Step 2 of the screening process as defined by USEPA guidance (Figure B-1). Step 2 identifies those Site-related COIs that pose potential risk and should be further evaluated by the BERA and those COIs that clearly represent negligible or no ecological risks and can be eliminated from further consideration with a high degree of confidence. Those COIs that will be or may be evaluated in the BERA are termed COPCs.

A Site-specific Sediment SAP (Integral and Anchor 2010) was prepared for the Site and submitted to USEPA on an accelerated schedule such that it preceded the RI/FS Work Plan and the SLERA. To develop the sediment study design, including the specific chemicals to be analyzed in sediments, it was necessary to have results of the screening level risk calculation. To allow for identification of sediment analytes in the Sediment SAP, a risk-based screening evaluation addressing benthic macroinvertebrates, fish, and wildlife was performed. The approach, assumptions, and methods are fully reported in the Sediment SAP (Integral and Anchor 2010); the relevant section of the SAP is provided in full as Appendix C to the RI/FS Work Plan.

This section provides summary information on the approach used and decisions resulting from the risk-based screening, along with the screening process and results. Appendix C of the RI/FS Work Plan contains a detailed, step-wise description of the selection of COIs and the risk-based screens used for identification of COPCs for ecological (and human) receptors.

3.1 Summary of Ecological Risk-Based Screening Approach

The screening level risk evaluation was based on chemistry data for seven sediment samples collected from within the impoundments (TCEQ and USEPA 2006). Sediments from the impoundments can reasonably be expected to have the highest concentrations of chemicals because the impounded area is the location at which waste materials were deposited in the 1960s and is the source of hazardous materials at the Site. Consistent with ERA guidance (USEPA 1998), maximum concentrations or, in the case where the chemical was not detected in all Site samples, one-half the maximum detection limit was used to provide a conservative estimate of exposure concentrations for ecological receptors for the screening evaluation.

The screening level effects evaluation was performed differently for benthic invertebrates than for fish and wildlife because of inherent differences in exposure pathways and routes, and differences in the toxicity of contaminants to these different taxa (Attachment B2). For each of these two broad categories of receptors, benthic macroinvertebrates and fish and wildlife, the screening level effects evaluation results in an SMDP for each chemical, entering the chemical into one of the three following categories:

1. There are sufficient data to conclude that there is an absence of risk to ecological receptors.
2. There are insufficient data to determine whether there is a risk to ecological receptors.
3. Data are sufficient to conclude that additional analysis of risks in the BERA is necessary.

The resulting scientific management decisions can be summarized as follows:

- Chemicals in Category 1 will not be considered further in the RI/FS.
- Chemicals in Category 2 will be considered secondary COPCs for the RI/FS.
- Chemicals in Category 3 will be considered primary COPCs for the RI/FS.

Thus, results of the screening evaluation are provided in terms required by USEPA guidance for conducting ERAs (USEPA 1997).

3.2 Summary of Approach to Screening Effects Evaluation and Results

A summary of the screening process and results is provided in Table B-4 for benthic macroinvertebrates and in Table B-5 for fish and aquatic-dependent wildlife. Dioxins and furans, 13 metals, polychlorinated biphenyls (PCBs), and nineteen additional organic compounds are retained as COPCs for further evaluation; primary COPCs will be addressed by the BERA, and secondary COPCs will be further evaluated after the results of the sediment sampling are available. When new information on secondary COPCs is available, these will undergo the risk based screening again, and will be evaluated in the BERA if they are detected at least once, and if they do not pass the risk based screen. A summary of the COIs retained as COPCs for further evaluation in the BERA and those COIs not retained is provided in Table B-6. A thorough description of the screening process and results is provided in Appendix C of the RI/FS Work Plan.

3.2.1 Benthic Macroinvertebrates

As a result of the ecological risk-based screening, evaluation of risk to benthic macroinvertebrates will be conducted in the BERA for ten metals, dioxins and furans, and one additional organic compound. These are the primary COPCs for benthic macroinvertebrates. The chemicals retained as COPCs and the reasons for retaining these chemicals for further evaluation are outlined in Table B-4 and can be summarized as follows:

- No SLV was available and there were detected Site concentrations for:
  - Aluminum
  - Barium
  - Cobalt
  - Magnesium
  - Manganese
  - Vanadium
- The maximum Site concentration exceeded the SLV for:
  - Copper
  - Lead
  - Mercury
  - Zinc
  - Bis(2-ethylhexyl)phthalate

In addition, one metal (thallium), twelve semivolatile organic compounds (SVOCs) and six volatile organic compounds (VOCs) could not be ruled out from further evaluation and were retained as secondary COPCs for the following reasons:

- Thallium: No SLV was available and no detected concentrations were found, so there is insufficient information for an evaluation of the potential for risk.
- Twelve SVOCs were retained as secondary COPCs: 2,3,4,6-tetrachlorophenol was never analyzed in Site sediments, so there is no information with which to evaluate

the potential for risk. The other 11 SVOCs had no available SLVs and no detected concentrations, so there is insufficient information for an evaluation of the potential for risk (Table B-4).

- Six VOCs identified as COIs were never analyzed in Site sediments, so there is no information with which to evaluate the potential for risk (Table B-4).

On the basis of information provided in Attachment B2 to this SLERA, dioxins and furans will be considered in evaluation of the risks to benthic macroinvertebrates in the BERA.

3.2.2 Fish and Aquatic-Dependent Wildlife

For fish and wildlife, five metals, dioxins and furans, and one additional organic compound were retained as primary COPCs for further evaluation in the BERA. The chemicals retained as COPCs and the reasons for retaining these metals for further evaluation are outlined in Table B-5 and can be summarized as follows:

- Dioxins and Furans: This class of compounds is potentially bioaccumulative in fish and aquatic-dependent wildlife, and dioxins were detected in multiple Site samples.
- Five metals with detected Site concentrations were identified as potentially bioaccumulative in fish and aquatic-dependent wildlife:
  - Cadmium
  - Copper
  - Mercury
  - Nickel
  - Zinc
- Bis(2-ethylhexyl)phthalate was additionally identified as a primary COPC because it had detected concentrations in Site sediment and was identified as potentially bioaccumulative in fish and aquatic-dependent wildlife.

In addition, three organic compounds could not be ruled out from further evaluation and were retained as secondary COPCs for the following reasons:

- The following were not detected in sediments from the impoundments, but are potentially bioaccumulative and therefore will be retained for further evaluation in the BERA:
  - Total PCBs
  - Pentachlorophenol
  - Hexachlorobenzene

4 UNCERTAINTY EVALUATION

The most significant uncertainties encountered in performing the SLERA stem from data gaps and limitations in the currently available data for the Site. A SLERA necessarily applies conservative judgments where there are data gaps or other uncertainties that could affect the SMDP results from the SLERA. A very conservative approach is used so that COIs can be eliminated from further consideration in the BERA with a high degree of confidence that the COI poses no risk to any ecological receptors.

In this SLERA, uncertainties created by use of a limited data set were addressed by the use of the following specific conservative approaches, methods, or assumptions:

- Development of a comprehensive COI list for the starting point for screening. Both site-specific sediment chemistry data and general technical information were consulted to identify priority pollutant chemicals that may be present in the materials deposited in the impoundments in the 1960s. On the basis of a list of the priority pollutants possibly in the source material at the Site, a conservative set of criteria was used to identify and define the COIs before the risk-based screening process was applied (Appendix C).
- Use of chemistry information from sediments collected from within the waste impoundments, which is reasonably expected to have the highest concentrations of COIs at the Site, to represent the screening level exposures.
- Use of the maximum concentration of each chemical in sediments from within the waste impoundments, where COIs are expected to be most concentrated.
- In the risk-based screen for benthic macroinvertebrates, application of conservative screening level values that convey the concentrations in sediment associated with no effect on the benthic macroinvertebrate community.
- In the risk-based screen for fish and wildlife, use of the conservative assumption that if a chemical is considered potentially bioaccumulative, then exposure to fish and wildlife are possible, so the chemical should be considered in the BERA.

Uncertainties resulting from a lack of information on chemical concentrations in abiotic and biotic media potentially contaminated by chemicals originating from within the impoundments, on the fate and transport of contaminants, and on the nature and extent of contamination will be addressed in the RI, as described in the RI/FS Work Plan. Results of investigations conducted under the RI/FS Work Plan will be incorporated into the BERA to reduce uncertainty and establish a more realistic assessment of ecological risks associated with the Site.

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TABLES

Table B-1
Data sets with Information on the Chemical Setting Evaluated for the San Jacinto River Waste Pits Site

Media Sampled	Source of Data	Sampling Dates	Chemicals Analyzed	Area Sampled	Citation
Sediment					
	TCEQ SJRWP Site Sampling	Aug 20, 2009	Dioxins/Furans	4 sediment stations (5 samples, 1 a field duplicate) in Site, within and adjacent to impoundments	URS (2010)
	TCEQ Site Screening Investigation	July 2005	Dioxins/Furans, Metals, PAH, SVOCs, Pesticides, PCBs	6 stations in the Impoundments (7 samples, 1 a field duplicate)	TCEQ and EPA (2006)
	Houston Ship Channel Study	Aug and Oct 1993, May 1994	Dioxins/Furans	Of 35 stations along the Houston Ship Channel and major tributaries, 2 stations are located in the Site, 1 in the channel adjacent to the impoundments and 1 upstream of impoundments	ENSR and EHA (1995)
	Texas Department of Transportation Dolphin Project	May - June 2006	Dioxins/Furans, Metals, SVOCs, PCBs	4 sediment cores and 8 surface sediment samples in San Jacinto River just above Interstate Highway 10	Weston (2006)
	TCEQ TMDL Study	2002-2005	Dioxins/Furans	1 station adjacent to the Site (11193) sampled for surface water, biota and sediment; additional intensive sediment sampling in site in summer 2005	University of Houston and Parsons (2006)
	TCEQ TMDL Study	2008-2009	PCBs	4 sediment samples: 2 samples at each of two stations; one station on site (11193) and one station upstream (16622).	University of Houston and Parsons (2008); Koenig (2010, Pers. Comm.)
Surface Water					
	TCEQ TMDL Study	2002-2004	Dioxins/Furans	1 surface water sample collected from the Site	University of Houston and Parsons (2006)
		Aug 20, 2009	Dioxins/Furans	1 surface water sample was collected from the Site	URS (2010)
Tissue					
	Houston Ship Channel Study	October 1993	Dioxins/Furans	1 sample of edible tissue of blue crab and 1 sample of blue catfish filet were collected from the Site	ENSR and EHA (1995)
	TCEQ TMDL Study	2002-2004	Dioxins/Furans, PCBs, Pesticides	6 samples of edible tissue from blue crab and 2 samples of edible tissue from blue catfish were collected from the Site	University of Houston and Parsons (2006)
		2002-2004	Dioxins/Furans, PCBs	4 samples of edible tissue from hardhead catfish were collected from the Site	University of Houston and Parsons (2006)
	TDSHS Study	1999-2004	Dioxins/Furans, Herbicides, Metals, PAH, PCBs, Pesticides, SVOCs, VOCs	4 samples of edible tissue from blue crab, 3 blue catfish filets, 1 freshwater drum filet, 3 hybrid striped bass filets, 2 red drum filet, 1 small mouth buffalo fish filet, 1 southern flounder filet, and 2 spotted seatrout filets were collected from the Site	TDSHS (2005)

Notes

PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SJR = San Jacinto River
SJRWP = San Jacinto River Waste Pits
SVOC = semivolatile organic compound
TCEQ = Texas Commission on Environmental Quality
TMDL = total maximum daily load

Table B-2
Chemicals of Interest

Class	Chemical
Dioxins/Furans	
	Dioxins and Furans
Metals	
	Aluminum
	Antimony
	Arsenic
	Barium
	Cadmium
	Chromium
	Cobalt
	Copper
	Lead
	Magnesium
	Manganese
	Mercury
	Nickel
	Silver
	Thallium
	Vanadium
	Zinc
Polychlorinated Biphenyls (PCBs)	
	Polychlorinated Biphenyls
Semivolatile Organic Compounds (SVOCs)	
	Acenaphthene
	Fluorene
	Naphthalene
	Phenanthrene
	2,4,6-Trichlorophenol
	2,4-Dichlorophenol
	Pentachlorophenol
	Phenol
	Hexachlorobenzene
	2,3,4,6-Tetrachlorophenol
	Carbazole
	2,4,5-Trichlorophenol
	Bis(2-ethylhexyl)phthalate
Volatile Organic Compounds (VOCs)	
	Chloroform
	1,2,4-Trichlorobenzene
	1,2-Dichlorobenzene
	1,3-Dichlorobenzene
	1,4-Dichlorobenzene
	1,2,3-Trichlorobenzene

Table B-3
Summary of Ecological Receptor Surrogates

Receptor Group	Receptor Surrogate	Feeding Guild	Potentially Present	Representative of One or More Feeding Guilds	High Site Fidelity/Residential	Sensitive or Potentially Highly Exposed	Life History Information Is Readily Available	Additional Considerations
Benthic macroinvertebrates								
	Molluscs	Filter feeders	X	X	X	X [a]	X	Close association with sediment
Fish								
	Gulf killifish	Omnivore	X	X	X		X	Common prey for other fish and bird species
	Black drum	Benthic invertivore	X	X	X		X	Popular sport fish; limited range, limited interbay movement
	Southern flounder	Benthic piscivore	X	X	X [b]	X	X	Supports commercial and recreational fisheries
Reptiles								
	Alligator snapping turtle	Omnivore	X	X	X	X	X [c]	Sensitive species (state threatened)
Birds								
	Neotropic cormorant	Piscivore (diving)	X	X			X	
	Great blue heron	Piscivore (wading)	X	X			X	
	Spotted sandpiper	Invertivore (probing)	X	X		X	X	As a sediment-probing invertivore, expected to be closely associated with sediment exposure pathway
	Killdeer	Invertivore (terrestrial)	X	X	X		X	Feeds on invertebrate fauna closely associated with soils
Mammals								
	Marsh Rice Rat	Omnivore	X	X	X		X	Semi-aquatic, diet consists of aquatic and emergent plants, and invertebrates
	Raccoon	Omnivore	X	X			X	Representative of both aquatic and terrestrial omnivorous feeding guilds

Notes

a - Sensitive reproductive endpoint, see Attachment B2.
b - Site fidelity is probably high except in winter, when this species moves into more saline waters to spawn.
c - Life history information is readily available for another turtle in the snapping turtle family, the common snapping turtle (*Chelydra serpentina*).

Table B-4
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006) [b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
Metals (mg/kg)						
Aluminum	NV	22,100	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Antimony	NV	7.2 *U*	1/7	NSLV	No	No SLV; however, there is only a single detection in Site data and this is not a chemical expected to be associated with pulp mill waste
Arsenic	8.2	3	4/7	No	No	Maximum site concentration does not exceed SLV
Barium	NV	244	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Cadmium	1.2	0.7 *U*	4/7	No	No	Maximum site concentration does not exceed SLV
Chromium	81	22.1	7/7	No	No	Maximum site concentration does not exceed SLV
Cobalt	NV	6.8 *J*	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Copper	34	62.5	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Lead	46.7	59.3	7/7	No	Yes	Maximum site concentration exceeds SLV
Magnesium	NV	4,790	7/7	NSLV	Yes	No screening value, detected at least once in Site sediments
Manganese	NV	790	7/7	NSLV	Yes	No screening value, detected at least once in Site sediments
Mercury	0.15	1.7	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Nickel	20.9	14	7/7	No	No	Maximum site concentration does not exceed SLV

Table B-4
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006)[b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
Silver	1	1.4 *U*	2/7	Yes	No	Highest concentration is close to SLV. High percentage of non-detects. Highest detected concentration is 0.29, below SLV
Thallium	NV	3.5 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Vanadium	NV	34.4	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Zinc	150	244	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Dioxins/Furans (ng/kg)						
2,3,7,8-TCDD	25,000 [c]	18,500	7/7	No	No [d]	Maximum site value does not exceed SLV
Polychlorinated Biphenyls (PCBs) (µg/kg)						
Total PCBs	1,200 [e]	90 *U* [f]	0/7	N/A	No	Highest detection limit does not exceed screening value
Semivolatile Organic Compounds (µg/kg)						
Acenaphthene	16	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Fluorene	19	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Naphthalene	160	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Phenanthrene	240	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments

Table B-4
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006) [b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
2,4,6-Trichlorophenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
2,4-Dichlorophenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Pentachlorophenol	NV	1,150 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Phenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Hexachlorobenzene	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
2,3,4,6-Tetrachlorophenol	NV	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
Carbazole	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations
2,4,5-Trichlorophenol	NV	1,150 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations
Bis(2-ethylhexyl)phthalate	182	1800	3/7	Yes	Yes	Maximum site concentration exceeds SLV
Volatile Organic Compounds (µg/kg)						
Chloroform	4300 [g]	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2,4-Trichlorobenzene	390	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2-Dichlorobenzene	740	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation

Table B-4
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006)[b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
1,3-Dichlorobenzene	320	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,4-Dichlorobenzene	700	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2,3-Trichlorobenzene	NV	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation

Notes

DL = detection limit
EqP = equilibrium partitioning
OC = organic carbon
NA = not applicable
NOEC = no effect concentration
NV = no value
NSLV = no screening level value available
SLV = screening level value
J = estimated
U = analyte not detected

a - NOEC (no effect concentration) is from TCEQ 2006 and is based on Long et al. (1995) unless otherwise indicated. Units of screening value match those of sediment data as given in compound class header (e.g., metals in mg/kg).

b - Nondetects are provided at 1/2 the detection limit.

c - Barber et al. (1998)

d - Although dioxins and furans passed the screening step, on the basis of information provided in Attachment B2, evaluation of risks to benthic invertebrates resulting from exposure to 2,3,7,8-TCDD is appropriate (Table B-6).

e - Fuchsman et al. (2006). Lowest unbounded NOEC (growth) for a PCB mixture of 81 mg/kg OC (*Macoma nasuta*). Using EqP and conservative estimate of organic carbon of 1.5 percent (Louchouarn and Brinkmeyer 2009), the dry weight equivalent of this value is 1.2 mg/kg.

f - As there were no detections of PCBs, this value is the highest reporting limit in the data set for any of the Aroclors evaluated.

g - Table 3-3 in TCEQ (2006)

Table B-5
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Metals (mg/kg)						
Aluminum	22,100	7/7	NA	No	No	Not potentially bioaccumulative
Antimony	7.2 *U*	1/7	NA	No	No	Not potentially bioaccumulative
Arsenic	3	7/7	NA	No	No	Not potentially bioaccumulative
Barium	244	7/7	NA	No	No	Not potentially bioaccumulative
Cadmium	0.7 *U*	4/7	NA	Yes	Yes	Potentially bioaccumulative,
Chromium	22.1	7/7	NA	No	No	Not potentially bioaccumulative
Cobalt	6.8 *J*	7/7	NA	No	No	Not potentially bioaccumulative
Copper	62.5	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Lead	59.3	7/7	NA	No	No	Not potentially bioaccumulative
Magnesium	4,790	7/7	NA	No	No	Not potentially bioaccumulative
Manganese	790	7/7	NA	No	No	Not potentially bioaccumulative
Mercury	1.7	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Nickel	14	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments

Table B-5
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Silver	1.4 *U*	2/7	NA	No	No	Not potentially bioaccumulative
Thallium	3.5 *U*	0/7	NA	No	No	Not potentially bioaccumulative
Vanadium	34.4	7/7	NA	No	No	Not potentially bioaccumulative
Zinc	244	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Dioxins/Furans (ng/kg)						
TEQ birds at ND=1/2DL	62,200	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
TEQ fish at ND=1/2DL	22,300	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
TEQ mammals at ND=1/2 DL	24,000	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Polychlorinated Biphenyls (µg/kg)						
Total PCBs	90 U[d]	0/7	>5	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
Semivolatile Organic Compounds (µg/kg)						
Acenaphthene	455 *U*	0/7	3.92	No[e]	No	Not potentially bioaccumulative

Table B-5
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Fluorene	455 *U*	0/7	4.18	No[e]	No	Not potentially bioaccumulative
Naphthalene	455 *U*	0/7	3.3	No[e]	No	Not potentially bioaccumulative
Phenanthrene	455 *U*	0/7	4.57	No[e]	No	Not potentially bioaccumulative
2,4,6-Trichlorophenol	455 *U*	0/7	3.72	No[e]	No	Not potentially bioaccumulative
2,4-Dichlorophenol	455 *U*	0/7	3.06	No[e]	No	Not potentially bioaccumulative
Pentachlorophenol	1,150 *U*	0/7	5.12	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
Phenol	455 *U*	0/7	1.46	No[f]	No	Not potentially bioaccumulative
Hexachlorobenzene	455 *U*	0/7	5.73	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
2,3,4,6-Tetrachlorophenol	NV	NV	4.45	No[e]	No	Not potentially bioaccumulative
Carbazole	455 *U*	0/7	3.72	No[e]	No	Not potentially bioaccumulative
2,4,5-Trichlorophenol	1,150 *U*	0/7	3.69	No[e]	No	Not potentially bioaccumulative
Bis(2-ethylhexyl)phthalate	1800	3/7	7.6	Yes	Yes	Potentially bioaccumulative, detected in Site sediments

Table B-5
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Volatile Organic Compounds (µg/kg)						
Chloroform	NV	NV	1.97	No[e]	No	Not potentially bioaccumulative
1,2,4-Trichlorobenzene	NV	NV	4.02	No[e]	No	Not potentially bioaccumulative
1,2-Dichlorobenzene	NV	NV	3.43	No[e]	No	Not potentially bioaccumulative
1,3-Dichlorobenzene	NV	NV	3.53	No[e]	No	Not potentially bioaccumulative
1,4-Dichlorobenzene	NV	NV	3.44	No[e]	No	Not potentially bioaccumulative
1,2,3-Trichlorobenzene	NV	NV	4.05	No[e]	No	Not potentially bioaccumulative

Notes

COPC = chemical of potential concern
NA = not applicable
NV = no value
TCEQ = Texas Commission on Environmental Quality
TEQ = toxicity equivalent
J = estimated
U = analyte not detected
a - Undetected values are set to 1/2 the detection limit.
b - Log Kow: Octanol-water partition coefficient, the ratio of the concentration of a chemical in octanol and water at equilibrium and at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter (e.g.,
c - Determination of bioaccumulative potential is based on TCEQ guidance (TCEQ 2006) or, if chemical is not addressed in guidance, log Kow information is used to determine bioaccumulative potential (as indicated in footnote e), with those chemicals having
d - As there were no detections of PCBs, this value is the highest reporting limit in the dataset for PCBs+A66
e - Not provided in TCEQ guidance; log Kow used to determine potential for bioaccumulation as described in footnote d.

Table B-6
Summary of Primary and Secondary COPCs for the BERA

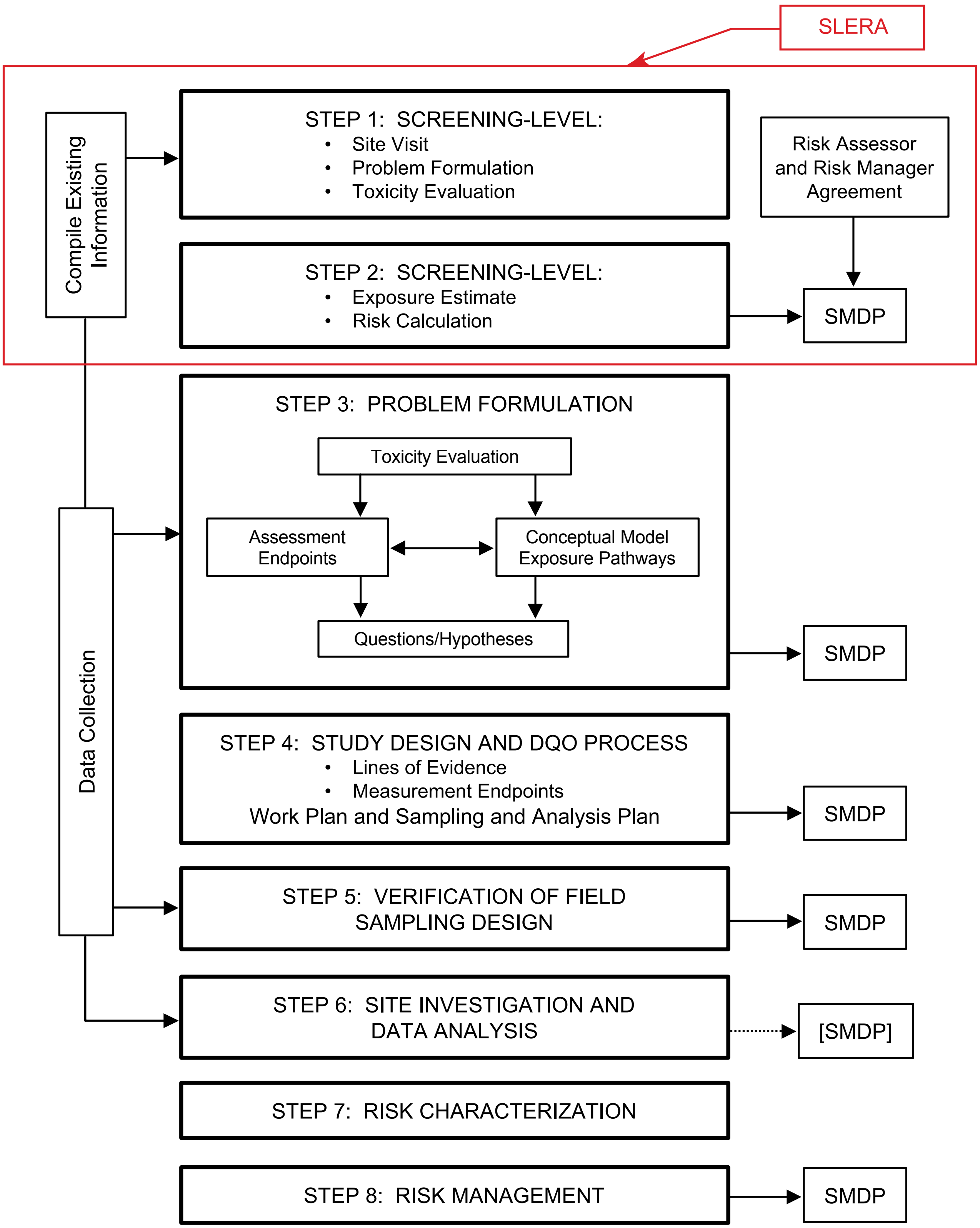
COI	Benthic Invertebrates		Fish and Wildlife	
	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC
Dioxins/Furans				
Dioxins and Furans	X[a]		X	
Metals				
Aluminum	X			
Antimony				
Arsenic				
Barium	X			
Cadmium			X	
Chromium				
Cobalt	X			
Copper	X		X	
Lead	X			
Magnesium	X			
Manganese	X			
Mercury	X		X	
Nickel			X	
Silver				
Thallium		X		
Vanadium	X			
Zinc	X		X	
Polychlorinated Biphenyls				
Polychlorinated Biphenyls				X
Semivolatile Organic Compounds				
Acenaphthene		X		
Fluorene		X		
Naphthalene		X		
Phenanthrene		X		
2,4,6-Trichlorophenol		X		
2,4-Dichlorophenol		X		
Pentachlorophenol		X		X
Phenol		X		
Hexachlorobenzene		X		X
2,3,4,6-Tetrachlorophenol		X		
Carbazole		X		
2,4,5-Trichlorophenol		X		
Bis(2-ethylhexyl)phthalate	X		X	
Volatile Organic Compounds				
1,2,4-Trichlorobenzene		X		
1,2-Dichlorobenzene		X		
1,3-Dichlorobenzene		X		
1,4-Dichlorobenzene		X		
Chloroform		X		
1,2,3-Trichlorobenzene		X		

Notes

BERA = baseline ecological risk assessment
COI = chemical of interest
COPC = chemical of potential concern

a - On the basis of information provided in Attachment B2, risks to benthic macroinvertebrates resulting from exposure to 2,3,7,8-TCDD will be evaluated in the BERA.

FIGURES



[SMDP] only if change to the sampling and analysis plan is necessary.

Figure B-1
The Screening Level Ecological Risk Assessment in the Context of the USEPA 8-Step Process for Ecological Risk Assessment
SJRWP SLERA
SJRWP Superfund/MIMC and IPC

DRAFT

P:\Projects\C643_SJWaste_IPC\Production_MXDs\SLERA\Figure_B2_Overview.mxd - 6/28/2010 @ 1:18:25 PM

ANCHOR QEA
integral consulting inc.

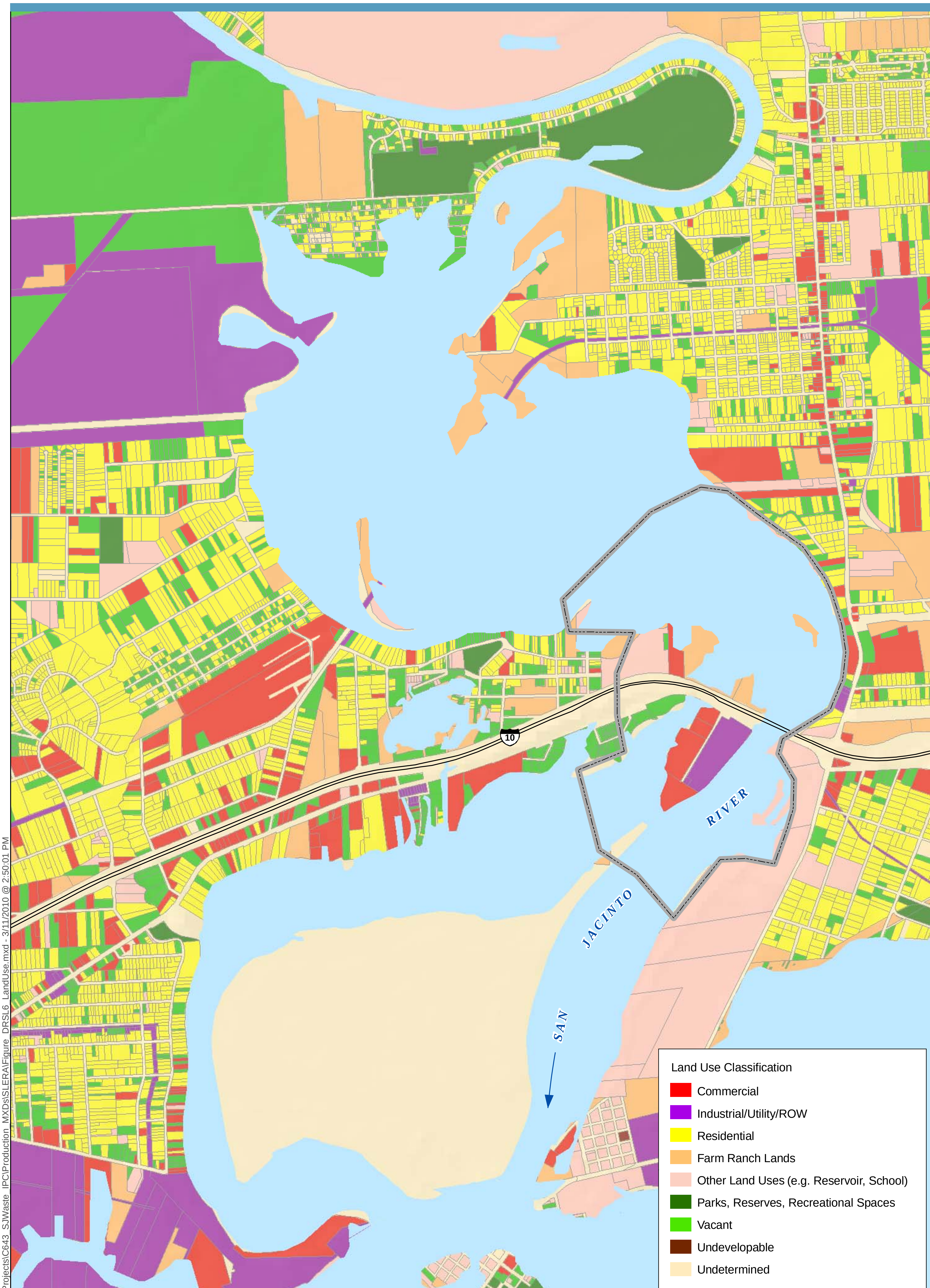
Preliminary Site Perimeter
Property West of the Impoundments
Perimeter of the Impoundments in 1973

0 800
Scale in Feet

FEATURE SOURCES:
Aerial Imagery: 0.5-meter January 2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIS

Figure B-2
Overview of Current Site
SJRWP SLERA
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



ANCHOR QEA integral consulting inc.

Preliminary Site Boundary

Parcel Boundary

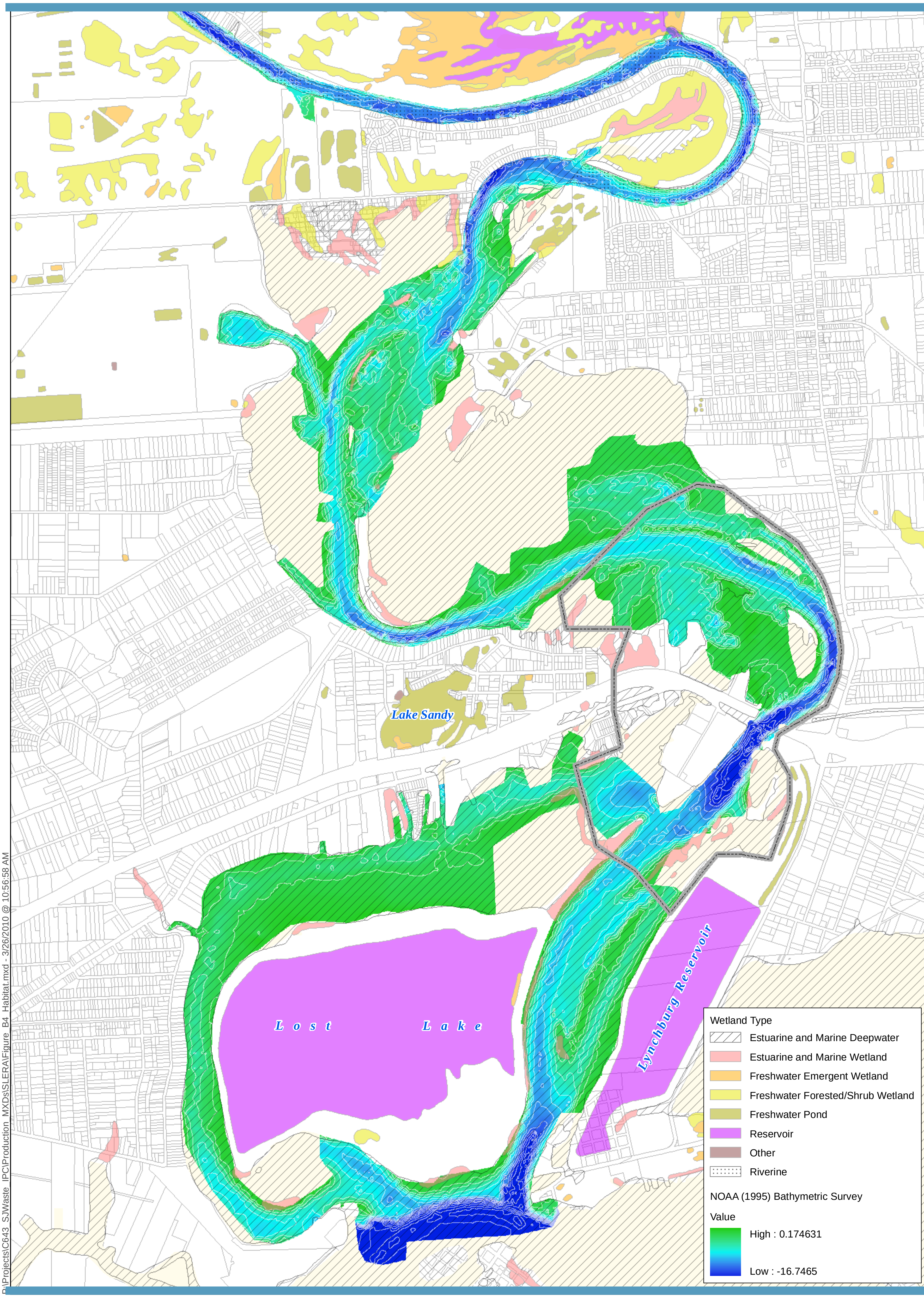
0 0.5

Scale in Miles

FEATURE SOURCES:
Zoning: Houston-Galveston Area Council
Parcel Boundaries: Harris County Appraisal District

Figure B-3
Land Use in the Vicinity of the Site
SJRWP SLERA
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



Preliminary Site Perimeter

1-Meter 1995 Bathymetric Contour

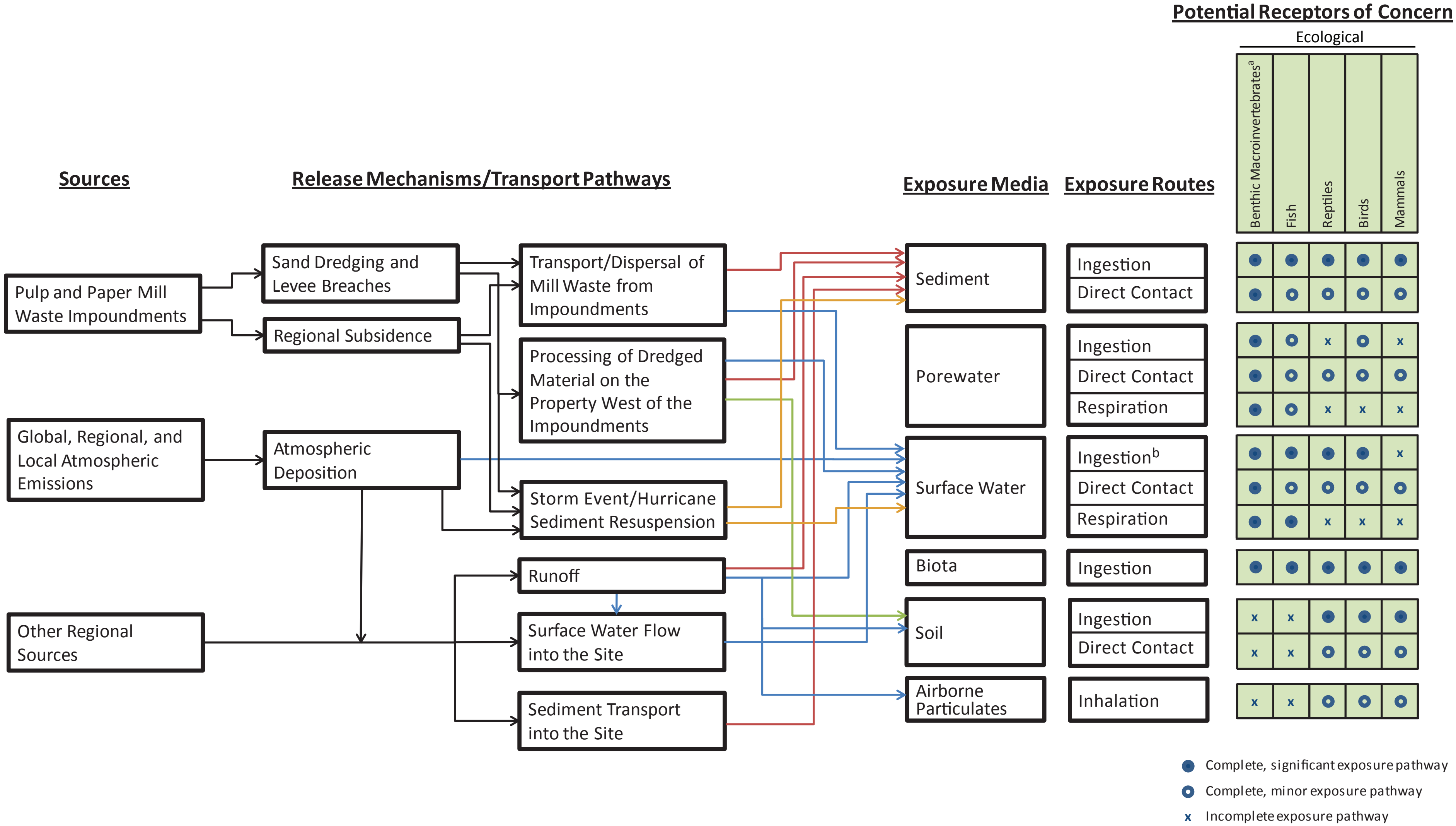
Figure B-4
Habitats in the Vicinity of the Site
SJRWP SLERA
SJRWP Superfund/MIMC and IPC

0 0.125 0.25 0.5
Miles

N

FEATURE SOURCES:
Bathymetry and Contours: NOAA. 1995. Hydrographic Survey
No. H10619: in the vicinity of Lynchburg Landing to Muleshoe Lake, Texas.
Wetlands: U.S. Fish and Wildlife Service.
Parcel Boundaries: Harris County Appraisal District.

DRAFT
DO NOT QUOTE OR CITE



Notes:

Other regional sources may include industrial effluents, publicly owned treatment works, and stormwater.
Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.
Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds and mammals.

ANCHOR QEA
integral consulting inc.

Figure B-5

Conceptual Site Model for Ecological Exposures: Summary of Exposures

SJRWP SLERA

SJRWP Superfund/MIMC and IPC

Exposure Media	Exposure Routes	Benthic Macro-invertebrates	Fish		Reptiles	Aquatic Birds		Terrestrial Birds	Mammals
			Omnivores	Benthic Piscivores		Piscivore	Wading Invertivores/ Omnivores	Invertivore	
Sediment	Ingestion	●	○	●	●	●	●	x	●
	Direct Contact	●	○	○	○	○	●	x	○
Porewater	Ingestion	●	○	○	x	○	○	○	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	○	○	x	x	x	x	x
Surface Water	Ingestion[a]	●	●	●	●	●	●	x	x
	Direct Contact	●	○	○	○	○	○	○	○
	Respiration	●	●	●	x	x	x	x	x
Biota	Ingestion	●	●	●	●	●	●	●	●
Soils	Ingestion	x	x	x	●	x	x	●	●
	Direct Contact	x	x	x	○	○	○	○	○
Airborne Particulates	Inhalation[b]	x	x	x	○	○	○	○	○

Notes:

● Potentially complete and significant exposure pathway

○ Potentially complete but minor exposure pathway

x Incomplete exposure pathway

[a] Mammals and terrestrial birds are assumed not to ingest surface water for drinking, as surface water is estuarine.

[b] Inhalation of contaminated vapor or particles is a minor exposure route for reptiles, birds, and mammals.

Figure B-6

Conceptual Site Model for Ecological Exposures:
Exposure Details for Receptor Feeding Guilds and Habitat Associations
SJRWP SLERA
SJRWP Superfund/MIMC and IPC

ATTACHMENT B-1

SPECIES THAT MAY BE EXPECTED IN THE VICINITY OF THE SAN JACINTO RIVER WASTE PITS SITE

Table B1-1
Aquatic and Wetland Plants That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Federal and/or State Listing	Source of Information
Water-milfoil	*Myriophyllum pinnatum*		USFWS 2008
Threeflower broomweed	*Thurovia triflora*	R	Harris County ET List (TPWD 2010)
Eastern woodland sedge	*Carex blanda Dewey*		USFWS 2008
Thinfruit sedge	*Carex flaccosperma Dewey*		USFWS 2008
Frank's sedge	*Carex frankii Kunth*		USFWS 2008
Shoreline sedge	*Carex hyalinolepis Steud.*		USFWS 2008
Greater bladder sedge	*Carex intumescens Rudge*		USFWS 2008
Cypress swamp sedge	*Carex joorii L.H. Bailey*		USFWS 2008
Blunt broom sedge	*Carex tribuloides Wahlenb.*		USFWS 2008
Fox sedge	*Carex vulpinoidea Michx.*		USFWS 2008
Common spikerush	*Eleocharis palustris*		USFWS 2008
Blunt spikerush	*Eleocharis obtusa*		USFWS 2008
Shortbristle horned beaksedge	*Rhynchospora corniculata*		USFWS 2008
Scouring-rush	*Equisetum hyemale*		USFWS 2008
Carolina foxtail	*Alopecurus carolinianus*		USFWS 2008
Giant cutgrass	*Zizaniopsis miliacea*		USFWS 2008
Jungle rice	*Echinochloa colona*		USFWS 2008
Field paspalum	*Paspalum laeve Michx.*		USFWS 2008
Southern canary grass	*Phalaris caroliniana*		USFWS 2008
Cattail	*Typha latifola*		USFWS 2008
Tapertip rush	*Juncus acuminatus*		USFWS 2008
Forked rush	*Juncus dichotomus*		USFWS 2008
Common rush	*Juncus effusus*		USFWS 2008
Inland rush	*Juncus interior*		USFWS 2008
Grassleaf rush	*Juncus marginatus*		USFWS 2008
Path rush	*Juncus tenuis*		USFWS 2008
Flat rush	*Juncus validus*		USFWS 2008
Common duckmeat	*Spirodela polyrrhiza*		USFWS 2008
Duckweed	*Lemna aequinoctialis*		USFWS 2008
Water-meal	*Wolffia brasiliensis*		USFWS 2008
Water-meal	*Wolffia columbiana*		USFWS 2008
Marsh purslane	*Ludwigia palustris*		USFWS 2008
Hairy water primrose	*Ludwigia grandiflora*		USFWS 2008
Texas prairie dawn	*Hymenoxys texana*	LE, E	Harris County ET List (TPWD 2010)
Water lettuce	*Pistia stratiotes*		Gonzalez et al 2006
Common water hyacinth	*Eichornnia crassipes*		Gonzalez et al 2006

References

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Harris County ET List. TPWD. 2010. Annotated County Lists of Rare Species. http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/endangered_species/ Texas Parks and Wildlife Department.

USFWS. 2008. *Plants of Trinity River National Wildlife Refuge* . Available at: http://www.fws.gov/southwest/refuges/texas/trinityriver/Docs/TrinityRiver85x11Plants2008.pdf. Downloaded on January 7, 2009. U.S. Fish and Wildlife Service.

Federal or State Listing

LE/LT = Federally Listed Endangered/Threatened
E/T = State Endangered/Threatened
R = Rare (State; this does not indicate a regulatory listing status)

Table B1-2
Invertebrates That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations	Source of Information
Blue crab	*Callinectus sapidus*	Blue crabs are benthic in every type of habitat from the saltiest water of the gulf to the almost fresh water of the back bays and estuaries, from the low tide line to waters 120 ft (36 m) deep. It is considered scavenger eating dead or dying organisms, but will also take live prey.	Crocker and Young 1990
Oyster	*Crassostrea virginica*	Eastern oysters are abundant in shallow saltwater bays, lagoons and estuaries, in water 8-25 ft (2.5-7.5 m) deep and between 28 and 90 degrees F. Have been collected in the vicinity of the Site.	Crocker and Young 1990, Broach 2010
Stone crab	*Menippe mercenaria*	Stone crabs prefer bottoms of bays, oyster reefs and rock jetties where they can burrow or find refuge from predators. Juveniles do not usually dig burrows, but instead hide among rocks or in seagrass beds	TPWD 2009
Hermit crab	*Clibanarius vittatus*	Benthic scavengers found in the intertidal	GBIC 2009
Fiddler crab	*Uca longisignalis*	Fiddler crabs are most often found in soft sand or mud near or around the edges of shallow salt marshes	TPWD 2009
Asian clam	*Corbicula fluminea*	Sand and clay, salinities up to 13ppt.	USGS 2009
Common rangia	*Rangia cuneata*	Low salinity estuaries, <19 ppt, most found in 5 - 15 ppt. Found in sandy, muddy, and vegetated areas. Species has been collected from the vicinity of the Site.	USFWS 1983, Broach 2010
Brown rangia	*Rangia flexuosa*	Typically found in the intertidal zone at the water's edge. Species has been collected from the vicinity of the Site.	Broach 2010
Dark false mussel	*Mytilopsis leucophaeata*	Typically found in brackish waters	Broach 2010
Dwarf surf clam	*Mulinia lateralis*	The dwarf surf clam is normally found in the soft strata in benthic communities.	Broach 2010
Surf clam	*Macoma mitchelli*		Young 2010
Hooked mussel	*Ischadium recurvum*	Typically found in the intertidal zone at the water's edge	Culbertson 2010
Southern quahog	*Mercenaria texana*		Culbertson 2010
Grass shrimp	*Palaemonetes pugio*	This species is a small shrimp species common to the estuaries of the Gulf Coast. With its small size and short life span (6-12) this species will likely spend its entire life cycle in the same area. It has limited commercial, recreational, or consumptive value for humans, but is a food source for many larger species. Inhabits low salinity areas with grassy shorelines.	GBIC 2009

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http://nepis.epa.gov/Exe/ZyNET.exe/5000231N.PDF?ZyActionP=PDF&Client=EPA&Index=1986%20Thru%201990&File=D%3A\ZYFILES\INDEX%20DATA\86THRU90\TXT\00000018\5000231N.txt&Query=san%20jacinto%20river%20fish%20tissue%20analysis&SearchMethod=3&FuzzyDegree=0&User=ANONYMOUS&Password=anonymous&QField=pubnumber^%22906R90001%22&UseQField=pubnumber&IntQFieldOp=1&ExtQFieldOp=1&Docs=

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Young, H. 2010. Personal communication (email exchange between D. Rudnick, Integral Consulting Inc. and H. Young, NOAA, discussing molluscs likely to be found in upper Galveston Bay). January 13, 2010.

J. Culbertson. 2010. Personal communication (email exchange between D. Rudnick, Integral Consulting Inc. and J. Culbertson, Texas Parks and Wildlife Department, discussing molluscs likely to be found in upper Galveston Bay. January 12, 2010.

Table B1-3
Reptiles and Amphibians That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations[a]	Federal and/or State Listing	Source of Information
Amphibians				
Gulf Coast toad	*Bufo valliceps valliceps*	From coastal prairies and barrier beaches along the Gulf of Mexico to roadside and irrigation ditches to urban/suburban sewers and backyard gardens		University of Texas 1999
Southern leopard frog	*Rana sphenocephala utricularia*	All types of shallow freshwater habitats, including temporary pools, cypress ponds, ponds, lakes, ditches, irrigation canals, and stream and river edges; will inhabit slightly brackish coastal wetland		USFWS 2009; TPWD 2009
Reptiles				
American alligator	*Alligator mississippiensis*	Alligators are found in or near water. They are common in swamps, rivers, bayous, and marshes. While typically found in fresh-water, they can tolerate brackish water as well.		USFWS 2009
Western cottonmouth	*Agkistrodon piscivorus leucostoma*	Western cottonmouths prefer lowland swamps, lakes, rivers, sloughs, irrigation ditches, rice fields and salt marshes, but are not confined to living in moist habitats		USFWS 2009
Gulf Salt Marsh snake	*Nerodia clarkii*	Just as the name indicates, gulf salt marsh snakes prefer brackish and saltwater estuaries, salt marshes and tidal mud flats.	R	USFWS 2009
Texas garter snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August	R	Harris County ET List (TPWD 2010)
Timber rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e., grapevines or palmetto	T	Harris County ET List (TPWD 2010)
Smooth green snake	*Liochlorophis vernalis*	Gulf Coastal Plain; mesic coastal shortgrass prairie vegetation; prefers dense vegetation	T	Harris County ET List (TPWD 2010)
Common snapping turtle	*Chelydra serpentina*	The snapping turtle can be found in waters ranging from slow moving rivers to stagnate ponds.		USFWS 2009
Alligator snapping turtle	*Macrochelys temminickii*	Alligator snapping turtles live in freshwater areas in the southeastern United States. They generally live in the deepest water within their habitat: large rivers, canals, lakes, swamps, and rivers.	T	USFWS 2009
Western chicken turtle	*Deirochelys reticularia maria*	Chicken turtles are semi-aquatic turtles, found both in water and on land. They prefer water with dense vegetation and soft substrate.		USFWS 2009
Eastern river cooter	*Psuedemysconcinna metteri*	The river cooter is primarily a river turtle, but can be found in ditches and saltwater areas near river mouths. Rivers with slow to moderate currents, abundant aquatic vegetation, and rocky bottoms are preferred. Other less frequently used habitats include lakes, ponds, deep springs, floodplain river pools, and swamps.		USFWS 2009
Common musk turtle	*Sternotherus odoratus*	The habitat of the common musk turtle includes any kind of permanent body of water, like shallow streams, ponds, rivers, or clear water lakes, and it is rare to find the turtle elsewhere.		USFWS 2009
Red-eared sldier	*Trachemys scripta elegans*	The red-eared slider enjoy large areas where they are free to swim. These turtles also require a basking area, where they can completely leave the water and enjoy the light provided for them.		USFWS 2009
Texas spiny softshell turtles	*Trionyx spiniferus emoryi*	Soft-shelled turtles are almost entirely aquatic powerful swimmers, fond of basking and rarely venture far from aquatic margins.		USFWS 2009
Diamondback terrapin	*Malaclemys terrapin littoralis*	Diamondback terrapins prefer brackish or salt water. They are the only turtle found in estuaries, tidal creeks, and saltwater marshes where the salinity comes close to that of the ocean.	R	TPWD 2009

References

Harris County ET List. TPWD. 2010. *Annotated County Lists of Rare Species* . Texas Parks and Wildlife Department.
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Notes

[a] Additional habitat Information accessed at www.amphibiaweb.org and http://animaldiversity.ummz.umich.edu/site/index.html

Federal or State Listing

LE/LT = Federally Listed Endangered/Threatened
E/T = State Endangered/Threatened
R = Rare

Table B1-4
Fish That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations and Diet[a]	Federal and/or State Listing	Source of Information
Benthic				
Omnivores				
Pinfish	*Lagodon rhomboides*	Commonly found on vegetated bottoms, occasionally over rocky bottoms and in mangrove areas. Enters brackish water and even freshwaters. Feeds mainly on small animals, especially crustaceans, but also takes mollusks, worms and occasionally small fishes that are associated with the grassy habitat.		Osborn et al. 1992
Atlantic croaker	*Micropogonias undulatus*	Occurs usually over mud and sandy mud bottoms in coastal waters and in estuaries where the nursery and feeding grounds are located. Feeds mainly on worms, crustaceans and fishes.		Osborn et al. 1992
Hardhead catfish	*Ariopsis felis*	Inhabits continental waters and enters estuaries. Found in turbid waters over muddy bottoms. Commonly captured from catwalks, bridges and piers, particularly in passes and inland waterways. It has a varied diet including detritus, invertebrates, and fish.		Crocker and Young 1990
Carnivores				
Blue catfish	*Ictalurus furcatus*	Diet is variable, tends to eat fish earlier in life. Although invertebrates still comprise the major portion of the diet, blue catfish as small as four inches in length have been known to consume fish. Individuals larger than eight inches eat fish and large invertebrates. Inhabits deep water of impoundments and main channels and backwaters of medium to large rivers, over mud, sand and gravel.		TPWD 2009a
Channel catfish	*Ictalurus punctatus*	Estuaries, lagoons, brackish seas, rivers, streams, lakes and ponds. Feed primarily on small fish, crustaceans (e.g. crayfish), clams and snails; also feed on aquatic insects and small mammals		TPWD 2009a
Southern flounder	*Paralichthys lethostigma*	Found mostly over mud bottoms in estuaries and coastal waters to about 40 m depth. A cryptic species; tolerates low salinities; occurs frequently in brackish bays and estuaries, even on occasion in fresh water. Taken by anglers inshore from bridges, jetties and small boats; this species moves to deeper water in winter, but is still easily accessible. Feeds chiefly on fishes, also on crabs and shrimps. Juveniles take mainly small bottom-living invertebrates		Osborn et al. 1992
Bowfin	*Amia calva*	Found in swampy, vegetated lakes and rivers. An air-breather that can withstand high temperatures, which enables it to survive in stagnant areas and is even known to aestivate; lethal temperature is 35.2°C. A voracious and opportunistic feeder, it uses scent as much as site and subsists on fish, frogs, crayfish, insects, and shrimps.		TPWD 2009b
Pelagic				
Omnivore				
Grass carp	*Ctenopharyngodon idella*	Occurs in lakes, ponds, pools and backwaters of large rivers, preferring large, slow-flowing or standing water bodies with vegetation. Tolerant of a wide range of temperatures from 0° to 38°C, and salinities to as much as 10 ppt and oxygen levels down to 0.5 ppm. Feeds on higher aquatic plants and submerged grasses; takes also detritus, insects and other invertebrates.		USFWS 2009a
Invertivore				
Gulf killifish	Fundulus grandis	Small fish species common in estuaries and rivers of the Gulf Coast. They do not migrate, remaining in the same location for their entire life. They eat various small invertebrates. Tolerates a wide range of salinities, from freshwater to estuarine.		Hassan-Williams et al. 2007
Carnivore				
Dollar sunfish	*Lepomis marginatus*	Inhabits sand-bottomed and mud-bottomed, usually brushy, pools of creeks and small to medium rivers; and also swamps. Feeds on midge larvae and microcrustacean.		TPWD 2009a
Warmouth	*Lepomis gulosus*	Usually occurs over mud in vegetated lakes, ponds, swamps and quiet water areas of streams. Feeds on fish and benthic invertebrates.		TPWD 2009a
White crappie	*Pomoxis annularis*	Occurs in sand-bottomed and mud-bottomed pools and backwaters of creeks and small to large rivers, and lakes and ponds. Often found in turbid water Adult feeds on forage fishes such as shad Younger crappie consumes small invertebrates, including microcrustaceans and small insects.		USFWS 2009b
Alligator gar	*Atractosteus spatula*	Adults inhabit sluggish pools and backwaters of large rivers, swamps, bayous, and lakes. Rarely enter brackish and marine waters Feed on blue crabs, turtles, waterfowl or other birds and small mammals		USFWS 2009b
Red drum	*Sciaenops ocellatus*	Occurs usually over sand and sandy mud bottoms in coastal waters and estuaries. Abundant in surf zone. Feeds mainly on crustaceans, mollusks and fishes.		TPWD 2009a
Bluegil	*Lepomis macrochirus*	Found frequently in lakes, ponds, reservoirs and sluggish streamspreferably live in deep weed beds. Active mainly during dusk and dawn. Adults feed upon snails, small crayfish, insects, worms and small minnows. Young feed on crustaceans, insects and worms.		TPWD 2009a

Table B1-4
Fish That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations and Diet[a]	Federal and/or State Listing	Source of Information
Black drum	*Pogonias cromis*	Usually found over sand and sandy mud bottoms in coastal waters, especially in areas with large river runoffs. Juveniles often enter estuaries. Primarily a benthic feeder, mainly on crustaceans, mollusks and fishes.		Osborn et al. 1992
Spotted seatrout	*Cynoscion nebulosus*	Inhabits river estuaries and shallow coastal marine waters over sand bottoms, often associated with seagrass beds. Also occurs in salt marshes and tidal pools of high salinity. Feeds mainly on crustaceans and fishes.		Osborn et al. 1992
Bay anchovy	*Anchoa mitchilli*	More commonly found in shallow tidal areas with muddy bottoms and brackish waters, tolerates a wide range of salinities (virtually fresh to fully saline or hypersaline). Feeds mostly on Mysis and copepods, also small fishes, gastropods and isopods.		Osborn et al. 1992
Largemouth bass	*Micropterus salmoides*	Inhabits clear, vegetated lakes, ponds, swamps. Also in backwaters and pools of creeks and rivers. Prefers quiet, clear water and over-grown banks. Adults feed on fishes, crayfish and frogs; young feed on crustaceans, insects and small fishes.		TPWD 2009a

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Notes

[a] Additional habitat association information from www.fishbase.org

Federal or State Listing

LE/LT = Federally Listed Endangered/Threatened
E/T = State Endangered/Threatened
R = Rare

Table B1-5
Aquatic-dependent Birds That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations and Diet	Federal and/or State Listing
Omnivore			
Gadwall	*Anas strepera*	Dabbling duck, primarily herbivorous but feeds on invertebrates during breeding season. Wetlands, ponds, marshes and lakes with heavily vegetated margins.	
Green winged teal	*Anas crecca*	Opportunistic feeder; seeds of aquatic vegetation, also invertebrates. Found in shallow ponds and marshes with abundant vegetation, tidal creeks and mudflats.	
Northern pintail	*Anas acuta*	Nests in open country with shallow, seasonal wetlands and low vegetation. Winters in wide variety of shallow inland freshwater and intertidal habitats.	
Blue-winged teal	*Anas discors*	Variable diet, including aquatic invertebrates, seeds and algae. Shallow ponds and wetlands.	
Mallard	*Anas platyrhynchos*	From large marshes to small river bends and bays; found in a wide variety of habitats. Variety of vegetation, increased feeding on invertebrates during breeding season.	
Black-bellied whistling duck	*Dendrocygna autumnalis*	Primarily feeds on plant material, but also consumes insects and molluscs. Breeds in coastal Texas. Primarily breeds in shallow freshwater ponds and lakes.	
Northern shoveler	*Anas clypeata*	Freshwater marshes, tidal bays in winter	
Lesser scaup	*Aythya, affinis*	Salt marshes, estuaries and lakes	
Ring-billed gull	*Larus delawarensis*	Breeds on islands in inland lakes, in winter along seacoasts	
Laughing gull	*Larus atricilla*	Nests in marshes, on beaches, and on islands along coast Found along coasts, in estuaries, bays, and inland lakes. Feeds along the ocean, on rivers, at landfills, and in urban parks.	
Gull-billed tern	*Sterna nilotica*	Breeds on gravelly or sandy beaches. Winters in salt marshes, estuaries, lagoons and plowed fields, less frequently along rivers, around lakes and in fresh-water marshes.	
Roseate spoonbill	*Platalea ajaja*	Marsh habitat. Omnivore with a wide diet inluding plants, invertebrates and fish.	
Killdeer	*Charadrius viciferous*	Fields, coastal fields, beaches, lawns. Insects make up the majority of the killdeer's diet, but they will also eat berries and crustaceans.	
Invertivore			
Pied-billed grebe	*Podilymbus podiceps*	Breeds on seasonal or permanent ponds with dense stands of emergent vegetation, bays and sloughs. Uses most types of wetlands in winter.	
Least sandpiper	*Calidris minutilla*	Breeds in mossy or wet grassy tundra, occasionally in drier areas with scattered scrubby bushes. Migrates and winters in wet meadows, mudflats, flooded fields, shores of pools and lakes, and, less frequently, sandy beaches.	
Mottled duck	*Anas fulvigula*	Freshwater wetlands, ditches, wet prairies, and seasonally flooded marshes.	
Black-necked Stilt	*Himantopus mexicanus*	Shallow fresh and saltwater wetlands, including salt ponds, rice fields, shallow lagoons, and mangrove swamps	
Greater yellowlegs	*Tringa melanoleuca*	Breeds in muskeg, wet bogs with small wooded islands, and forests (usually coniferous) with abundant clearings. Winters in wide variety of shallow fresh and saltwater habitats.	
Lesser yellowlegs	*Tringa flavipes*	Breeds in open boreal forest with scattered shallow wetlands. Winters in wide variety of shallow fresh and saltwater habitats.	
Spotted sandpiper	*Actitis macularia*	Breeds in a variety of habitats, such as shoreline, sagebrush, grassland, forest, lawn, or park. Winters wherever water is present. The spotted sandpiper is a shorebird that obtains much of its diet by probing or “mining” soft sediments along shorelines. Spotted sandpipers feed on a wide variety of benthic invertebrates and appear to be relatively common winter residents in coastal Texas.	
Western sandpiper	*Calidris mauri*	Breeds in coastal sedge-dwarf tundra. Migrates and winters along mudflats, beaches, shores or lakes and ponds, and flooded fields.	
White-faced ibis	*Plegadus chihi*	Primarily freshwater wetlands, but can also be found in estuarine habitats. Feeds on crustaceans, earthworms and insects	T
Carnivore			
Brown pelican	*Pelacanus occidentalis*	Oceans, inshore waters; stands on pilings or rocks	E

Table B1-5
Aquatic-dependent Birds That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations and Diet	Federal and/or State Listing
Double crested cormorant	*Phalacrocorax auritus*	Found in diverse aquatic habitats, such as ponds, lakes, rivers, lagoons, estuaries, and open coastline; more widespread in winter	
Neotropic cormorant	*Phalacrocorax brasilianus*	Various wetlands, including fresh, brackish, and saltwater habitats. Nests and roosts mostly in trees, but also on cliffs and human-made structures. Feeds primarily on fish <8cm in length.	
Great blue heron	*Ardea herodias*	Wetlands where tall trees, rock ledges or extensive reeds provide a safe site for the heronry. Feeds on fish but also crustaceans, amphibians.	
Great egret	*Casmerodius albus*	Marshes where deeper water is edged with low , vegeatated banks. Nesting colonies may be in reeds or cattails, but more commonly in trees.	
Tricolored heron	*Egretta tricolor*	Breeds primarily in coastal habitats; feeds mainly on small fishes.	
Little blue heron	*Egretta caerulea*	Swamps, estuaries, rivers, ponds, and lakes	
Snowy egret	*Egretta thula*	Near freshwater lakes or estuaries	
Cattle egret	*Bubucus ibis*	Extensive marshes, wooded marshes	
Green heron	*Butorides virescens*	Breeds in swampy thickets. Forages in swamps, along creeks and streams, in marshes, ponds, lake edges, and pastures. Winters mostly in coastal areas, especially mangrove swamps.	
Black-crowned night-heron	*Nycticorax nycticorax*	Various wetland habitats, including salt, brackish, and freshwater marshes, swamps, streams, lakes, and agricultural fields.	
Yellow-crowned night-heron	*Nyctanassa violacea*	Marsh	
White ibis	*Eudocimus albus*	Large marshes	
Red-breasted merganser	*Mergus serrator*	Lakes rivers, winters on saly water	
Osprey	*Pandion haliaetus*	Coasts and inland lakes and rivers	
Forster's tern	*Sterna forsteri*	Breeds in marshes, generally with lots of open water and large stands of island-like vegetation.Winters in marshes, coastal beaches, lakes, and rivers.	
Least tern	*Sterna antillarum*	Beaches, bordering, shallow water along rivers, lakes, or coasts	
Belted kingfisher	*Megaceryle alcyon*	Breeds along streams, rivers, lakes, and estuaries with banks for nest holes. Winters along coast, streams, and lakes.	
Bald eagle	*Haliaeetus leucocephalus*	Coasts and inland lakes and rivers	BGEPA
Reddish egret	*Egretta rufescens*	Marsh habitat	

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Notes

Birds are all listed on the bird checklist of the Baytown Nature Center (2006).

Additional habitat information from Cornell Lab of Ornithology's 2009 Bird Search. Accessed at http://www.allaboutbirds.org/NetCommunity/Page.aspx?pid=1189 Accessed on December 30 2009, and from Birds of North America Online, http://bna.birds.cornell.edu/bna.

Federal or State Listing

BGEPA = Bald and Golden Eagle Protection Act
LE/LT = Federally Listed Endangered/Threatened
E/T = State Endangered/Threatened
R = Rare

Table B1-6
Aquatic-dependent Mammals That May Be Found in the Vicinity of the San Jacinto River Waste Pits Site

Common Name	Scientific Name	Habitat Associations	Federal and/or State Listing	Source of Information
Herbivore				
Nutria	*Myocastor coypus*	Nutria spend most of their time in or near the water. Favored foods for nutria include rushes, reeds, cattails, arrowhead, square-stem spike rush and sawgrass.		USFWS 2009
American beaver	*Castor canadensis*	Herbivore found in ponds, lakes, or large streams.		USFWS 2009
Omnivore				USFWS 2009
Marsh rice rat	*Oryzomys palustris*	Marsh rice rats are semi-aquatic rodents that eats aquatic plants, and some invertebrates such as crabs and snails. This animal nests in cattatils and bulrushes, and is prey to hawks and owls.		eNature.com
Virginia opossum	*Didelphis virginiana*	Opossums are omnivorous, primarily woodland creatures, but are also frequently found in prairies, marshes, and farmlands. Although they prefer to live in hollow trees and logs, opossums will also shelter in woodpiles, rock piles, crevices in cliffs, under buildings, in attics, and in abandoned underground burrows dug by other animals.		USFWS 2009
Northern raccoon	*Procyon lotor*	Raccoons prefer brushy or wooded areas near streams, lakes or swamps, although they can live close to developed areas if sufficient food, water and cover are provided. Though they prefer woodlands, raccoons can live practically anywhere and have adapted well to human habitats.		USFWS 2009
Muskrat	*Ondatra zibethicus*	They mostly inhabit wetlands, areas in or near salt and fresh-water marshlands, rivers, lakes, or ponds.		USFWS 2009
Carnivore				USFWS 2009
River otter	*Lutra canadensis*	River otters prefer to live near bodies of water such as lakes, large rivers, and streams. Along the Texas Gulf Coast region, otters also live in marshes, bayous, and brackish inlets.		USFWS 2009
Insectivore				
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures	T	Harris County ET List (TPWD 2010)
Southeastern myotis	*Myotis austroriparius*	Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures	R	Harris County ET List (TPWD 2010)

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Federal or State Listing

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R = Rare

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
Loons and Grebes				
Common loon	O	--	--	O
Pied-billed grebe	U	--	C	C
Pelicans		--	--	--
American white pelican	U	U	U	C
Brown Pelican[E]	C	C	C	C
Cormorants				
Double-crested cormorant	C	C	C	C
Neotropic cormorant	C	C	C	C
Anhinga				
Anhinga	--	U	U	--
Herons and Egrets				
Great blue heron	C	C	C	C
Great egret	C	C	C	C
Reddish egret	R	R	R	R
Tricolored heron	C	C	C	O
Little blue heron	U	C	C	O
Snowy egret	C	C	C	C
Cattle egret	C	C	C	--
Green heron	U	C	C	--
Black-crowned night-heron	C	C	C	U
Yellow-crowned night-heron	C	C	C	O
Storks				
Wood stork	--	U	U	--
Ibis and Spoonbills				
White ibis	C	C	C	U
White-faced ibis [T]	R	O	O	R
Roseate spoonbill	C	C	C	C
Ducks and Geese				
Black-bellied whistling-duck	C	C	U	--
Greater white-fronted goose	--	--	O	O
Snow goose	--	--	O	O
Ross's goose	--	--	R	R
Canada goose	--	--	--	R
Wood duck	R	O	O	R
American wigeon	O	--	--	O
Gadwall	U	--	U	C
Green-winged teal	C	--	U	C
Mallard	C	U	C	C
Mottled duck	C	U	U	U
Northern pintail	U	--	U	C
Blue-winged teal	C	O	U	C
Northern shoveler	U	--	U	C
Redhead	--	--	--	R
Greater scaup	--	--	--	O
Lesser scaup	O	--	O	C

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
Common goldeneye	--	--	--	O
Hooded merganser	U	--	U	C
Red-breasted merganser	U	--	U	C
Ruddy duck	--	--	--	O
Wood Warblers				
Orange-crowned warbler	O	--	O	C
Yellow-rumped warbler	O	--	O	C
Black-throated green warbler	O	--	O	--
Blackburnian warbler	O	--	O	--
Yellow-throated warbler	O	--	O	--
Pine warbler	--	--	O	U
Bay-breasted warbler	O	--	O	
Blackpoll warbler	O	--	O	--
Black-and-white warbler	O	--	O	--
Prothonotary warbler	O	--	O	--
Worm-eating warbler	O	--	O	--
Northern waterthrush	O	--	O	--
Louisiana waterthrush	O	--	O	--
Kentucky warbler	O	--	O	--
Common yellowthroat	O	--	U	O
Hooded warbler	O	--	O	--
Wilson's warbler	O	--	O	--
Canada warbler	O	--	O	--
Vultures				
Black vulture	U	U	U	U
Turkey vulture	U	--	U	U
Osprey				
Osprey	C	U	C	C
Hawks and Kites				
White-tailed kite	--	R	--	--
Bald eagle[T]	--	--	--	R
Northern harrier	O	--	O	U
Sharp-shinned hawk	O	--	O	O
Cooper's hawk	O	--	O	O
Red-shouldered hawk	U	U	U	C
Broad-winged hawk	O	--	O	--
Swainson's hawk	O	--	O	--
Red-tailed hawk	O	--	O	C
Falcons and Caracaras				
Crested caracara	R	--	--	R
American kestrel	U	--	U	C
Merlin	O	--	O	U
Peregrine falcon[T]	R	--	R	U
Cranes				
Sandhill crane	--	--	--	R
Rails and Coots				

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
Clapper rail	O	O	O	O
King rail	--	R	R	--
Sora	O	--	--	O
American coot	O	--	--	O
Avocets and Stilts				
Black-necked stilt	C	C	U	-
American avocet	--	--	R	R
Plovers and Sandpipers				
Black-bellied plover	U	--	O	O
Semipalmated plover	O	--	O	O
Killdeer	C	C	C	C
American woodcock	--	--	--	R
Wilson's snipe	O	--	O	--
Long-billed dowitcher	C	--	U	--
Greater yellowlegs	C	U	U	C
Lesser yellowlegs	C	U	U	U
Solitary sandpiper	O	--	O	-
Spotted sandpiper	C	U	C	C
Willet	C	U	U	U
Ruddy turnstone	R	--	--	--
Sanderling	R	--	--	--
Semipalmated sandpiper	U	U	U	O
Western sandpiper	C	O	U	C
Least sandpiper	C	O	U	C
White-rumped sandpiper	R	--	--	--
Pectoral sandpiper	U	--	R	--
Dunlin	O	--	O	--
Stilt sandpiper	U	--	O	--
Wilson's phalarope	R	--	--	--
Tanagers				
Scarlet tanager	R	--	--	--
Summer tanager	R	--	--	--
Sparrows				
Chipping sparrow	O	--	--	U
Field sparrow	--	--	--	U
Savannah sparrow	C	--	C	C
Le Conte's sparrow	-	--	-	O
Grasshopper sparrow	R	--	-	-
Song sparrow	U	--	O	U
Lincoln's sparrow	O	--	O	U
Swamp sparrow	U	--	U	C
White-crowned sparrow	U	--	--	U
White-throated sparrow	O	--	O	C
Harris's sparrow	--	--	--	R
Gulls and Terns				
Ring-billed gull	U	O	U	C

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
American herring gull	U	--	R	U
Laughing gull	C	C	C	C
Gull-billed tern	C	C	-	-
Caspian tern	U	O	U	U
Royal tern	U	U	U	O
Forster's tern	C	C	C	U
Least tern	C	U	--	--
Black tern	--	O	--	O
Black skimmer	U	C	O	-
Pigeons and Doves				
Rock pigeon	C	C	U	U
Eurasian collared-dove	O	O	O	O
Mourning dove	C	C	C	C
White-winged dove	C	C	C	C
Inca dove	O	O	O	O
Cuckoos				
Yellow-billed cuckoo	U	C	O	--
Groove-billed ani	--	--	R	R
Owls, Nightjars and Swifts				
Barn owl	R	R	R	R
Eastern screech-owl	C	C	C	C
Great horned owl	U	U	U	U
Barred owl	O	O	O	O
Common nighthawk	O	O	O	--
Chimney swift	O	O	O	--
Hummingbirds				
Ruby-throat hummingbird	U	U	C	--
Rufous hummingbird	--	--	R	--
Kingfishers				
Belted kingfisher	U	O	C	C
Woodpeckers				
Red-bellied woodpecker	C	C	C	C
Yellow-bellied sapsucker	O	--	--	U
Downy woodpecker	U	U	U	C
Northern flicker	O	--	O	C
Pileated woodpecker	O	O	O	O
Flycatchers				
Olive-sided flycatcher	O	--	O	--
Eastern wood-pewee	O	--	O	--
Yellow-bellied flycatcher	R	--	R	--
Acadian flycatcher	O	--	O	--
Alder flycatcher	O	--	O	--
Eastern phoebe	U	--	U	C
Vermilion flycatcher	--	--	--	R
Great crested flycatcher	O	--	O	--
Great kiskadee	R	--	-	--

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
Western kingbird	O	--	O	--
Eastern kingbird	O	--	U	--
Scissor-tailed flycatcher	U	C	U	--
Cardinals and Allies				
Northern cardinal	C	C	C	C
Blue grosbeak	O	--	U	--
Indigo bunting	O	--	U	--
Painted bunting	O	R	--	--
Dickcissel	O	--	O	--
Blackbirds and Orioles				
Red-winged blackbird	C	C	C	C
Eastern meadowlark	O	--	O	O
Brewer's blackbird	--	--	--	O
Common grackle	C	C	C	C
Great-tailed grackle	C	C	C	C
Brown-headed cowbird	C	C	O	O
Baltimore oriole	O	--	O	--
Orchard oriole	O	C	O	--
Swallows				
Purple martin	U	C	--	--
Tree swallow	U	O	U	O
Northern rough-winged swallow	U	O	U	O
Cliff swallow	O	O	O	--
Cave swallow	O	--	--	--
Barn swallow	C	C	C	O
Kinglets				
Golden-crowned kinglet	O	--	--	O
Ruby-crowned kinglet	U	--	O	C
Waxwings				
Cedar waxwing	O	--	--	O
Wrens				
Carolina wren	U	U	U	U
Winter wren	--	--	--	R
House wren	--	--	--	O
Sedge wren	U	--	U	U
Marsh wren	U	--	U	U
Mockingbirds and Thrashers				
Gray catbird	R	--	R	--
Northern mockingbird	C	C	C	C
Brown thrasher	U	--	U	U
Thrushes				
Eastern bluebird	O	--	O	U
Swainson's thrush	O	--	O	--
Hermit thrush	--	--	--	O
Wood thrush	O	--	--	--
American robin	U	O	U	C

Table B1-7
Birds That May be Found in the Vicinity of the Lower San Jacinto River

	Spring	Summer	Fall	Winter
Gnatcatchers and Chickadees				
Blue-gray gnatcatcher	U	--	C	C
Carolina chickadee	U	U	U	C
Shrikes				
Loggerhead shrike	U	C	C	C
Crows and Jays				
Blue jay	C	C	C	C
American crow	U	U	U	U
Starlings				
European starling	C	C	C	C
Old World Sparrows				
House sparrow	U	C	U	U
Vireos				
White-eyed vireo	O	O	O	--
Yellow-throated vireo	O	--	--	--
Blue-headed vireo	O	--	--	U
Warbling vireo	O	--	R	--
Philadelphia vireo	O	--	R	--
Red-eyed vireo	O	--	R	
Finches				
House finch	--	--	O	O
American goldfinch	--	--	O	C

Source:

Litteer, D. 2009. Baytown Nature Center Bird Checklist. http://www.baytownnaturecenter.org/publications_information/bird_checklist.html. Accessed January 7, 2009.

Notes

-- = not observed
T = state listed as threatened
E = state listed as endangered
ND = no data
C = common
O = occasional
R = rare, winter
U = uncommon

ATTACHMENT B-2

TOXICITY OF DIOXINS TO ECOLOGICAL RECEPTOR GROUPS

Table B2-1
Toxicity Equivalency Factors for Dioxins and Furans

Compound	Mammalian TEFs	Avian TEFs	Fish TEFs
Chlorinated Dibenzo-*p* -Dioxins			
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.05	0.5
1,2,3,6,7,8-HxCDD	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01
1,2,3,4,6,7,8-HpCDD	0.01	<0.001	0.001
OCDD	0.0003	0.0001	<0.0001
Chlorinated Dibenzofurans			
2,3,7,8-TCDF	0.1	1	0.05
1,2,3,7,8-PeCDF	0.03	0.1	0.05
2,3,4,7,8-PeCDF	0.3	1	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
OCDF	0.0003	0.0001	<0.0001

Source: Van den Berg et al. (2006).

Notes:

TEF = toxicity equivalency factor

Table B2-2
Summary of Information on the Toxicity of 2,3,7,8-TCDD to Benthic Invertebrates

Exposure Medium	Test Organism	Taxonomic Classification	Dose Administration	Exposure Duration	NOAEC/LOAEC	Units	Endpoint	Notes	Reference
Sediment									
	Ampelisca abdita	Crustacea, Amphipoda	Spiked sediment	10 days	25,000/NA	ng/kg dw sediment	Growth and mortality		Barber et al. (1998)
	Nereis virens	Annelida, Polychaeta	Field-collected sediment	180 days	656/NA	ng/kg dw sediment	Mortality	Potential co-contamination with 2,3,7,8-TCDF and PCBs noted.	Pruell et al. (1993)
					422/NA	ng/kg dw tissue			
	Macoma nasuta	Mollusca, Bivalvia	Field-collected sediment	120 days	656/NA	ng/kg dw sediment	Mortality	Presence of 2,3,7,8-TCDF and PCBs in both contaminated sediments and in study organisms noted.	Rubenstein et al. (1990)
					142/NA	ng/kg dw tissue			
	Palaemonetes pugio	Crustacea, Caridea	Field-collected sediment	28 days	656/NA	ng/kg dw sediment	Mortality		
					138/NA	ng/kg dw tissue			
	Chironomus riparius	Arthropoda, Diptera	Spiked sediment	28 days	10,000/NA	ng/kg dw sediment	Mortality, growth, mentum deformities		Loonen et al. (1996)
					14,000/NA	ng/kg dw tissue			
Water									
	Daphnia magna	Crustacea, Cladocera	Laboratory water	48 hours followed by 7 day recovery	1,030/NA	ng/kg ww tissue[a]	General toxicity		Adams et al. (1986)
	Mya arenaria	Mollusca, Bivalvia	Laboratory water	Single pulse dose for 24 hours followed by 28 day observation period	200/NA	ng/L in water	Reduced body mass over time		Cooper and Wintermyer (2009)
					NA/4.8 - 20	ng/kg ww weight tissue[a]	Gonadal lesions (female)		
	Physa sp.	Mollusca, Gastropoda	Well water	36 days followed by recovery period	200/NA	ng/L in water	Parental mortality, hatching, juvenile mortality		Miller et al. (1973)
	Paranais sp.	Annelida, Oligochaeta	Well water	55 days	200/NA	ng/L in water	Total biomass		
	Aedes aegypti	Arthropoda, Diptera	Well water	17 days followed by recovery period	200/NA	ng/L in water	Pupation		
	Mya arenaria	Mollusca, Bivalvia	Sea water	24 hours followed by recovery period	2,000/NA	ng/L in water	Mortality, shell length, gonadal histopathology	Tissue concentrations were measured but were widely variable among organs.	Rhodes et al. (1997)
	Helisoma sp.	Mollusca, Gastropoda	Spiked soil flooded with water	32 days	4.2/NA	ng/L in water	Reproductive activity, feeding, growth		Yockim et al. (1978)
	Daphnia magna	Crustacea, Cladocera	Spiked soil flooded with water	32 days	4.2/NA	ng/L in water	Reproductive activity, feeding, growth		
	Physa sp.	Mollusca, Gastropoda	Water		1,300/NA	ng/L in water	Reproductive activity, growth, feeding		Isensee and Jones (1975)
	Daphnia magna	Crustacea, Cladocera	Water		1,300/NA	ng/L in water	Reproductive activity, growth, feeding		
Diet	*Chironomus dilutus*	Arthropoda, Diptera	Spiked diet	35 days	3,804/NA	µg/kg TOC diet	Mortality, growth emergence, eggs/female, hatchability	TCDD concentrations also given as dw of food (323 µg/kg dw diet) and also provided on a lipid basis in *Chironomus* , see below.	West et al. (1997)
	Lumbriculus variegatus	Annelida, Oligochaeta	Spiked diet	28 days	3,594/NA	µg/kg TOC diet	Number of organisms, total biomass	Trend for reduced number of animals, but not statistically significant. TCDD concentration also given as dw of food (1,319 µg/kg dw diet) and also provided on a lipid basis in *Lumbriculus* tissue, see below.	
	Chironomus dilutus	Arthropoda, Diptera	Spiked diet	35 days	5,084	µg/kg lipid	Mortality, growth emergence, eggs/female, hatchability	Highest concentration (average of exposure group) during exposure period, achieved at day 13.	West et al. (1997)

Table B2-2
Summary of Information on the Toxicity of 2,3,7,8-TCDD to Benthic Invertebrates

Exposure Medium	Test Organism	Taxonomic Classification	Dose Administration	Exposure Duration	NOAEC/LOAEC	Units	Endpoint	Notes	Reference
	Lumbriculus variegatus	Annelida, Oligochaeta	Spiked diet	28 days	9,533/NA	µg/kg lipid	Number of organisms, total biomass	Highest concentration (average of exposure group), achieved at end of exposure period.	
Administered/Injection									
	Mya arenaria	Mollusca, Bivalvia	Injection (muscle; single dose)		200/NA	ng/kg ww tissue[a]	Reduced body mass over time		Cooper and Wintermyer (2009)
			Siphon gavage (single dose)		NA/200	ng/kg ww tissue[a]	Reduced body mass over time		
	Crassostrea virginica	Mollusca, Bivalvia	Injection (Days 1 and 14)	28 day observation period	NA/2.0	ng/kg ww tissue[a]	Reduced body mass over time		Cooper and Wintermyer (2009)
					NA/2.0	ng/kg ww tissue[a]	Gonadal lesions		
					NA/2	ng/kg ww tissue[a]	Reduced larval survival		
	Crassostrea virginica	Mollusca, Bivalvia	Injection (Days 1 and 14)	28 day observation period	NA/2	ng/kg ww tissue[a]	Delayed gonadogenesis (females)	Marked effect of solvent on this endpoint.	Wintermyer and Cooper (2007)
					NA/10	ng/kg ww tissue[a]	Sex ratio (reduced females)		
					NA/2	ng/kg ww tissue[a]	Reduced vitellogenic oocytes (females; electron microscopy)	Other reproductive endpoints also affected a this exposure level.	
					2/10	ng/kg ww tissue[a]	Delayed gonadogenesis (males)		

Notes:
LOAEC = lowest-observed-adverse-effects concentration
NA = not available
NOAEC = no-observed-adverse effects concentration
PCB = polychlorinated biphenyl
TCDD = tetrachlorodibenzo-*p* -dioxin
TOC = total organic carbon
Animals exposed to field-collected sediment may have been exposed to mixtures.
[a] Soft body tissue only (excluding shell)
[b] All laboratory studies summarized here used 2,3,7,8-TCDD as the exposure chemical. Some field studies summarized also measured other organocontaminants and these have been summarized in the Notes column.

APPENDIX C

DRAFT SELECTION OF CHEMICALS OF POTENTIAL CONCERN

DRAFT SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

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U.S. Environmental Protection Agency, Region 6

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
µg/kg	micrograms per kilogram
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CLP	Contract Laboratory Program
COI	chemical of interest
COPC	chemical of potential concern
EqP	equilibrium partitioning
ERL	effects range low
Koc	partition coefficient of a chemical in the organic matter of soil/sediment
Kow	octanol-water partition coefficient
mg/kg	milligrams per kilogram
ng/kg	nanograms per kilogram
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SLERA	screening level ecological risk assessment
SLV	screening level value
SVOC	semivolatile organic compound
TAL	target analyte list
TCEQ	Texas Commission on Environmental Quality
TEQ	toxicity equivalent
TMDL	Total Maximum Daily Load
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1 INTRODUCTION

This appendix describes the process for selecting chemicals of interest (COIs) for the Remedial Investigation and Feasibility Study (RI/FS) and the process and results of identifying chemicals of potential concern (COPCs) to be addressed by the RI and the risk assessments. This appendix provides the documentation of the research, data, logic, and rationale employed to identify COPCs. This information is also presented in the Sediment Sampling and Analysis Plan (SAP) (Integral and Anchor QEA 2010), and is repeated here as it appears in that document for ease of reference. It is required as reference to the RI/FS Work Plan because the results affect several aspects of the RI process, not just the Sediment SAP. Uses of the results of COPC selection are described in the RI/FS Work Plan.

2 DETERMINATION OF CHEMICALS OF INTEREST

This section describes the basis for establishing the list of chemicals that will be considered COIs in the RI. Section 2.2 describes how COPCs for the RI, including for the baseline ecological risk assessment (BERA) and the baseline human health risk assessment (BHHRA), are identified and reports on an analysis of existing sediment chemistry data to define the COPCs.

Guidance from the U.S. Environmental Protection Agency (USEPA) for performance of an RI/FS under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (USEPA 1988a) does not specify the methods to be used to identify COIs and COPCs, nor does it address the specific chemicals that should be evaluated, regardless of available data, at any individual site. For this project, the process for selection of COIs started with identification of all chemicals on USEPA's target analyte list (TAL) for metals and the standard organic analytes (semivolatile organic compounds [SVOCs], volatile organic compounds [VOCs], pesticides, and Aroclors) in the Contract Laboratory Program (CLP organic compounds). The combination of these two lists was checked against the Clean Water Act priority pollutants to ensure that all of USEPA's priority analytes were included in the initial evaluation. The final list of the 176 chemicals comprising the priority pollutant list is provided in Table C-1.

The primary source of contaminants associated with the Site is the pulp mill sludge deposited in the impoundments during its operation in the 1960s. Consistent with the conceptual site model, the identification of COIs includes consideration of the constituents likely to be associated with such wastes based on existing sludge sampling and analysis results from the impoundments. A literature review was conducted relating to pulp and paper mill wastes generated prior to the point at which the paper industry moved away from the use of chlorine ions in its bleaching processes and began using chlorine dioxide.[1] The literature review is discussed in Section 2.1.

[1] In the 1990s, to prevent generation of dioxins and furans, mills stopped using elemental chlorine, which binds with organic materials and forms chlorinated compounds, and switched to using chlorine dioxide, which bleaches fibers and produces no new chemicals (Wiegand 2010, pers. comm.).

To identify COIs, a series of questions was addressed for each chemical individually, as illustrated in Figure C-1. A total of 141 chemicals were analyzed in the sediment samples collected by the Texas Commission on Environmental Quality (TCEQ) and USEPA (2006) from within the impoundments. If an individual chemical was analyzed in these sediments and was detected at least once, it is considered a COI (Figure C-1). For those chemicals never detected, and for those priority pollutants never analyzed in sediment from the impoundments, both the likelihood of its presence in the source material (waste from a bleached kraft pulp mill operating in 1965) and the persistence of the chemical were evaluated. Chemical characteristics of bleached kraft pulp mill solid wastes were identified in a literature review discussed below. The persistence of a chemical was evaluated by considering the tendency of each chemical reasonably expected in these pulp mill solid wastes to adsorb to organic carbon in the sediment, as expressed by the Koc value. Chemicals were classified as "persistent" if they were identified in the Hazardous Substances Data Bank as expected to adsorb to suspended solids and sediment based on its Koc and other physical properties (NIH 2010). No additional metrics were used to determine persistence because half-life durations for volatilization or biodegradation of any chemicals not sorbed to sediments were very short in comparison to the 44 years that have elapsed since the wastes were deposited in the estuary (NIH 2010).

As shown in Figure C-1, if a chemical on the priority pollutant list was both expected in bleached kraft pulp mill wastes and persistent, it is considered a COI (Table C-2). The background information leading to the selection of COIs, and the COI list, is summarized in the remainder of this section.

2.1 Chemical Characteristics of Bleached Kraft Pulp Mill Wastes

According to available historical documents about the Site, the solid waste materials that were deposited in the impoundments in 1965 had the following characteristics:

- Primarily fibrous (the dried material was reported to resemble low-grade cardboard)
- Near neutral pH
- Medium stiff to stiff
- Low permeability
- Organic base (grass could be grown on the material)

Because there are no data to describe the chemical constituents in the wastes generated by the Champion Paper Mill in Pasadena, Texas, at the time the impoundments at the Site were formed, industry experts and technical papers documenting bleached kraft pulp mill waste chemistry were consulted. The description of the types of wastes generated in these mills that follows is a generalized description assembled from these sources.

Several kinds of wastes were generated by bleached kraft pulp mills (NCASI 1999):

- Liquid effluents
- Solid wastes derived from caustic residuals from the kraft recovery process (lime mud, slaker grits, and green liquor dregs)
- Solids from wastewater treatment plant residuals
- Ash generated by burning bark, sawdust, fossil fuels, and in some cases, other waste materials from a mill site

The chemical constituents of both wastewater treatment plant solids and ash depended to some degree on the types of fiber used to make pulp and the other materials that were burned. Generally, the broad categories of hazardous materials expected in bleached kraft pulp mill wastes from that era (Wiegand 2010, pers. comm.) include dioxins, furans, and chlorinated phenols.

The available literature on the hazardous chemicals likely present in bleached kraft pulp mill solid wastes generated in the 1960s is limited; the specific chemicals identified through this research are summarized in Table C-3. Table C-3 presents those priority pollutants included in the analyses of sediment samples collected from within the impoundments by TCEQ and USEPA (2006), and are expected in bleach kraft pulp mill wastes according to the literature.

USEPA (1988b) and NCASI (1999) confirm that dioxins and furans were generated historically by bleached kraft pulp mills. A review of available chemistry data for solid wastes generated by 26 bleached kraft and other pulp mills (NCASI 1999) consistently found several types of metals, chlorinated phenols, dioxins, and several VOCs (Table C-3). NCASI (1999) also reports negligible concentrations of PCBs and chlorinated benzenes in some wastes, and trace levels of some polycyclic aromatic hydrocarbon (PAH) compounds in some ash samples. A study of the chemistry of leachates from landfills used specifically for pulp mill wastes (NCASI 1992) reported toluene (a VOC), as well as other phenolics including three cresol isomers, and trichlorophenols. No pesticides or PCBs were found in these landfill leachates.

A list of analytes provided by Suntio et al. (1988), reporting on the chemical constituents in liquid effluents of pulp mills, included chlorinated phenols, chlorinated benzenes, nitrotoluenes, and 15 VOCs. This paper was consulted, but was not included in Table C-3 because the subject was limited to liquid effluents, and liquid wastes were removed from the impoundments at the Site. Leachates from landfills of solid wastes are more likely to be characteristic of any liquid materials associated with the impoundments and were addressed by NCASI (1992).

2.2 Characteristics of Sediments in the Impoundments

Sediment samples were collected by TCEQ and USEPA (2006) from within the impoundments and analyzed for 141 chemicals, including dioxins and furans, metals, pesticides, SVOCs, and PCBs. VOCs were not analyzed. With the exception of one phthalate compound in one sample, none of the pesticides, SVOCs, or PCBs were detected. Most metals were detected in one or more samples, with the exceptions of beryllium, selenium, and thallium, which were never detected in sediment samples from the impoundments. Dioxins and furans were detected in all samples from the impoundments.

Louchouarn and Brinkmeyer (2009) also collected a sediment grab and a sediment core from within the eastern half of the impoundments in 2006. The only COIs analyzed in these sediments were dioxins and furans, but these investigators also report on the depth distribution of lignins and several forms of organic carbon within the core, which was sectioned at 2 cm (0.8 inch) intervals. The authors found the organic carbon content of the sediment to be variable at this depth resolution, ranging from about 1 to 3 percent, with a spike in the organic carbon content up to about 8 percent at the interval between 1 and 1.3 feet (30 and 40 cm). The materials in this depth appear to contain relatively high fractions of both terrestrial plant-derived lignins and other organic carbon.

Other than dioxins and furans, there were no detectable concentrations of nearly all of the organic chemicals evaluated by TCEQ and USEPA (2006), including the chlorinated phenols, nitrotoluenes, and assorted PAHs that were determined to possibly occur in beached kraft pulp mill wastes. The confirmed low levels of other organic chemicals, coupled with the very high dioxin and furan concentrations in the sediment and their persistence in the environment, suggest that patterns of dioxins and furans typical of the impoundments may provide a useful signal, or tracer, in the RI/FS for impacts on sediments of material derived from the impoundments.

2.3 Summary of Chemicals of Interest

A summary of the approach to selection of COIs and the list of COIs are provided in Table C-4; the final list of COIs is provided in Table C-2. COIs are those chemicals that are among USEPA's priority pollutants, were reported by one or more technical reports as occurring in pulp mill solid wastes or leachate from solid waste landfills, and are likely to have bound to sediment organic carbon and persist for more than 40 years in the environment. These COIs were further evaluated in each of three risk-based screens to identify COPCs, discussed below in Section 3. Results of the COPC identification affect the sediment sampling and analysis designs, as described in Section 4.

3 DETERMINATION OF CHEMICALS OF POTENTIAL CONCERN

Because the source of the COIs to the RI/FS for the Site is the impoundments created in 1965 for the disposal of waste sludges from the Champion Paper Mill in Pasadena, Texas, the evaluation to identify COPCs for the RI was performed using chemistry data for the seven sediment samples collected directly from the impoundments by TCEQ and USEPA (2006). Although there are chemistry data for other sediment samples collected within the preliminary Site perimeter, the sediment collected from within the impoundments are expected to contain the highest concentrations of any chemicals that are associated with the wastes in the impoundments. This assumption can be verified by comparing the concentrations of dioxins and furans in sediment from the impoundments with the highest concentrations in sediment collected elsewhere from within the preliminary Site perimeter. For example, the concentration of 2,3,7,8-tetrachlorinated dibenzofuran (TCDF) from station 15 in the TCEQ Total Maximum Daily Load (TMDL) study was 93,000 nanograms per kilogram (ng/kg) (the higher of two replicates at this station) (University of Houston and Parsons 2006). The highest concentration in sediment samples outside the impoundments but still within the preliminary Site perimeter is at TMDL Station 11 (1,600 ng/kg). This concentration is a factor of nearly 60 lower than the concentration in the impoundments. Therefore, for the purposes of the selection of COPCs, chemical concentrations in sediments at the six stations (seven samples; one a field duplicate) from within the impoundments are considered to represent the highest concentrations of source-related chemicals at the Site.

The process to select COPCs for the RI involves the following two steps:

- Determination of COIs to the investigation (Figure C-1)
- Performance of risk-based screens for each COI

To determine whether a COI should be the subject of the sediment investigation or other field investigations that will support the RI/FS, the BERA, and the BHHRA, each COI was evaluated using three conservative risk-based screening tools, as follows:

- Human health risk screen
- Fish and wildlife risk screen
- Benthic macroinvertebrate risk screen

The objective of using these screens is to identify those COIs that can be eliminated from further consideration with a high degree of confidence that the COI plays no role in Site-related risks to human health or ecological receptors at the Site. Each of the three risk-based screens combine information on the bioaccumulation potential of each COI and risk-based screening concentrations in sediment to interpret the chemistry of samples from within the impoundments (TCEQ and USEPA 2006). Each risk-based screen results in one of the following conclusions for each COI:

1. Data are sufficient to conclude that there is an absence of risk to receptors using the Site.
2. There are insufficient data to determine whether there is a risk to receptors; more information is needed.
3. Data are sufficient to determine that the COI should be evaluated in the baseline risk assessment.

Those COIs in the first category will not be analyzed further in the RI/FS. A complete evaluation of those COIs in the second category requires additional data, and the extent to which each may contribute to risk is unknown. Additional data are required that describe these COIs in sediment and possibly other media. These chemicals are discussed further in this appendix as "secondary COPCs." COIs falling into the third category are known to be present in sediments from the impoundments at concentrations associated with the potential for adverse effects to humans, fish, wildlife, or benthic invertebrates. These COIs will be evaluated in the baseline risk assessments, and additional information is required to do so. COIs determined to be in the third category are termed "primary COPCs."

Each of the three risk-based screens is described below, followed by a summary of the primary COPCs and secondary COPCs that result in Table C-5. The entire process and results are summarized for each screen in Tables C-5, C-6, and C-7. Every chemical listed as a primary COPC will be evaluated in one or both of the baseline risk assessments.

Steps to collect and analyze additional information about primary and secondary COPCs in sediments are discussed in Section 4. Greater detail on the screening process for ecological receptors is provided in the screening level ecological risk assessment (SLERA). Additional considerations for planning both the BERA and the BHHRA are included in greater detail in the RI/FS Work Plan. The sections below are not intended to replace those discussions.

3.1 Human Health Risk-Based Screen

The approach for evaluating COIs for human health is illustrated in Figure C-2. The screening process for a COI considers comparison with its risk-based screening level value (SLV), bioaccumulation potential, and whether the COI was ever detected in sediments from within the impoundments.

SLVs were obtained from two sources: USEPA Region 3 preliminary remediation goals (PRGs)[2], which were calculated consistent with USEPA (1991) guidance, and TCEQ (2006a) sediment protective concentration levels. PRGs are not available for sediment, so PRGs for residential soil were used as surrogates and are considered conservative because residential soil PRGs consider exposures through incidental ingestion, dermal contact, and inhalation of particulates, while direct sediment exposures are likely limited to incidental ingestion and dermal contact. Because human exposures at the Site may occur through ingestion of contaminated tissues, bioaccumulation potential is considered in the screening process. The list of chemicals with potential to bioaccumulate was obtained from TCEQ (2006b). PCBs were screened as total PCBs (all Aroclors summed). PCB congener data are not available for the sediment samples from within the impoundments.

Using this approach, the chemicals identified as primary COPCs for human health are arsenic, cadmium, chromium, copper, mercury, nickel, zinc, PCBs, bis(2-ethylhexyl)phthalate (BEHP), and 2,3,7,8-TCDD TEQ concentrations (Table C-5). The chemicals identified as secondary COPCs for human health are pentachlorophenol, hexachlorobenzene, 2,3,4,6-tetrachlorophenol, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and chloroform. Documentation of the human health screening process is provided in Table C-6.

[2] http://www.epa.gov/reg3hwmd/risk/human/index.htm

3.2 Benthic Macroinvertebrate Risk-Based Screen

The approach to evaluating each COI to determine whether it can be eliminated from further assessments of risk to benthic macroinvertebrates on the Site is illustrated in Figure C-3. Benthic macroinvertebrates are assumed to be in direct contact with sediments such that chemical concentrations in sediments provide the appropriate measure of exposure for the screening evaluation. SLVs protective of benthic macroinvertebrates were used as a primary screening step in this approach. The primary source of screening values was Long et al.'s effect range low (ERL) values for marine sediments (Long et al. 1995). These ERLs represent concentrations of chemicals in sediment that are not associated with adverse biological effects; as such, they provide a conservative screening benchmark against which Site concentrations can be evaluated. These values are the primary screening values provided in TCEQ guidance for ecological risk assessment (TNRCC 2001; TCEQ 2006). If no ERL was available, TCEQ's benchmarks for marine sediments were used as a secondary source of SLVs (TCEQ 2006)[3].

3.2.1 PCBs

One additional study was considered in identifying benthic invertebrate screening values for PCBs, because the Long et al. (1995) value for PCBs is at odds with more recent literature. Fuchsman et al. (2006) explore the differences between cause-effect studies that are used to derive benthic invertebrate no-effects levels for PCBs in sediment and the screening values derived by Long et al. (1995) and others using data for effects only and based on sediments containing a mixture of chemicals. Fuchsman et al. (2006) demonstrate that no-effects and effects PCB concentrations in sediment estimated using the equilibrium partitioning (EqP) method are more consistent with actual effects and no-effects values from PCB toxicity studies than the derived screening values such as those of Long et al. (1995). Ideally, the EqP method uses partitioning coefficients for individual congeners, but no-effects concentrations estimated for Aroclors and for total PCBs are also provided by Fuchsman et al. (2006). These values are considered conservative because the more chlorinated PCBs are generally the more toxic, but they are also more likely to be bound to organic carbon in sediments under ambient sediment conditions. These authors list several no-effects levels as micrograms per

[3] The marine benchmarks provided in TCEQ (2006b) are based primarily based on Long et al. (1995), as detailed in Table C-7.

kilogram (μg/kg) organic carbon-normalized (OC) for both marine and freshwater benthic invertebrates. Their lowest unbounded no-observed-effect concentration (growth) for a PCB mixture is 81 mg/kg OC for a marine clam (*Macoma nasuta*). Conservatively assuming an organic carbon content in sediments from the impoundments of 1.5 percent (Louchouarn and Brinkmeyer 2009), the dry weight equivalent of this value is 1.2 milligram per kilogram (mg/kg), which is greater than the highest non-detect for any Aroclor in sediment from the impoundments (TCEQ and USEPA 2006).

3.2.2 Dioxins

TCEQ (2006) does not provide a dioxin screening value, so the scientific literature was reviewed for appropriate dioxin benchmark(s) that could be used to screen sediment data for the Site. Preference was given to benchmarks that were empirically derived, relevant to marine/estuarine sediments, and provided a concentration associated with no effect in the tested organism. Proposed sediment quality guidelines and benchmarks for dioxins have been promulgated by a variety of institutions and agencies and many have been compiled by Wenning et al. (2004). Several of these benchmarks are based on equilibrium partitioning and other predicted relationships between sediments and receptors and were not considered as relevant or robust as the screening value described below.

A value of 25 μg/kg from a spiked sediment 10-day toxicity test using the marine amphipod *Ampelisca abdita* was chosen for comparison to Site data (Barber et al. 1998). In this study, 25 μg/kg 2,3,7,8-TCDD was the highest concentration to which the amphipod was exposed, and no significant effects on either survival or growth were found. This study was chosen to provide the screening benchmark because it used a sensitive and representative marine benthic invertebrate species and empirically identified a no-effect concentration of dioxin at and below which effects were not observed.

Documentation of the screening process for benthic macroinvertebrates is provided in Table C-7. Additional information on the benthic invertebrates, and on the toxicity of dioxins and furans to invertebrates, is provided in the screening level ecological risk assessment (SLERA) and attachments, which is Appendix B to the RI/FS Work Plan.

3.3 Fish and Wildlife Risk-Based Screen

The approach to determining whether each COI is a COPC or can safely be eliminated from further assessments of risk to fish and wildlife is illustrated in Figure C-4.

This approach differs from the approach used to identify COPCs for benthic invertebrates because, for the purposes of screening only, fish, birds, and mammals are assumed to be exposed to sediment-related chemicals primarily through ingestion of their foods, and exposures to COIs for the purpose of evaluating risk would be assessed using whole body or other tissue concentrations, as for dioxins and furans in fish. Therefore, the potential for bioaccumulation of each chemical is considered in the first step of risk-based screening approach for fish, birds, and mammals. Potential for bioaccumulation of metals was evaluated using TCEQ guidance, which lists chemicals considered to be bioaccumulative (Table 3-1 in TNRCC [2001] and TCEQ [2006]). Because TCEQ guidance does not address some of the organic COIs, for all of the organic COIs, the log Kow was used as an indicator of bioaccumulation potential. Consistent with USEPA guidance (USEPA 2008), chemicals with log Kows equal to or greater than 5 were considered to have the potential to bioaccumulate in tissue.

If the chemical had never been detected, it was included as a secondary COPC. If the chemical was potentially bioaccumulative but was never detected, it was included as a secondary COPC. If it was detected, it was included as a primary COPC. Documentation of the screening process for fish and wildlife is provided in Table C-8. The chemicals identified as primary and secondary COPCs for benthic invertebrates and for fish and wildlife are summarized in Table C-5.

4 EVALUATION OF COPCS IN THE SEDIMENT STUDY AND ITS RESULTS

The purpose of investigating chemicals in sediment is to determine the nature and extent of potential contamination, identify any unacceptable risks associated with the contamination, and evaluate potential remedies (USEPA 2005). Sections 2 and 3 describe a series of conservative analyses to focus the RI/FS on only those chemicals that may be present in sediments at levels that could generate unacceptable risks. This section describes how the results of these evaluations will affect the sediment study design and provides an overview of how the results of the sediment study will be analyzed to focus the risk assessments.

Figure C-5 provides an overview of how the chemicals listed in Table C-1 are addressed and the related analysis steps, including the following:

- Identification of COIs (Section 2)
- Application of conservative risk-based screening to select COPCs (Section 3)
- Identification of dioxins and furans as an indicator chemical group (Section 5, below)
- How the sediment study addresses COPCs (Section 6, below)

Because the risk-based screening evaluations were performed on the samples that describe the most contaminated sediments at the Site (i.e., those from the source), the selection and treatment of COPCs described in these sections are applicable to other aspects of the RI/FS. For example, these analyses also define the COPCs and analytes for the investigation of soils in upland areas. Additional information is provided in the main text of the RI/FS Work Plan and subsequent SAPs.

5 DIOXINS AND FURANS AS AN INDICATOR CHEMICAL GROUP

According to USEPA (1988a) guidance for conducting an RI/FS under CERCLA, it is sometimes appropriate to select one or more indicator chemicals to focus the assessment on those chemicals likely to be of greatest concern. An indicator chemical or chemical group is one that is the most toxic, persistent, and/or mobile among those substances likely to contribute significantly to the overall risk at the Site. Selection of an appropriate indicator chemical or chemical group can serve to simplify and focus much of the investigation, the required analyses, and the evaluation of remedial alternatives. Use of an effectively selected indicator chemical reduces both the costs and the time required to develop and implement a remedial strategy and, in doing so, is considered appropriate by USEPA guidance (USEPA 1988a).

Dioxins and furans provide an appropriate indicator chemical group for the RI/FS for this Site. Their concentrations relative to risk-based screening values are very high in sediments from the impoundments, and the degree to which they exceed risk-based screening levels in these sediments relative to those of the other COPCs is also very high, indicating that they are very likely to be the most important risk driver at the Site. For these reasons, dioxins and furans are the chemicals of greatest concern to the RI/FS. Moreover, concentrations of biologically active congeners can be expressed in a unifying metric, the TEQ concentration, providing a simple means to express exposures, evaluate risks, and to address remedial goals for a group of chemicals. The specific uses of dioxins and furans as an indicator chemical group for the sediment study are discussed in the Sediment SAP. The overall importance and full range of uses of dioxins and furans as an indicator chemical group is described in the main text of this RI/FS Work Plan and in subsequent documents.

6 HOW COPCS ARE ADDRESSED

Figure C-5 outlines the additional analysis steps for the COPCs summarized in Table C-5. The sediment study (Integral and Anchor QEA 2010) will generate new information on both primary and secondary COPCs in sediments. Primary COPCs will be analyzed in all sediment samples, and secondary COPCs will be included among the analytes in a subset of sediment samples collected for Study Element 1, Nature and Extent Evaluation. Specifically, secondary COPCs will be analyzed in samples from within the impoundments, from a subset of stations within the Site, and in all of the upstream background stations. At all of the stations for which sediments will be collected to characterize the nature and extent of contamination, enough mass of sediment will be collected for analysis of secondary COPCs in these samples, if necessary. This additional mass of sediment will be archived.

To determine whether archived sediments should be analyzed for secondary COPCs, the secondary COPCs in the nature and extent sediment samples will be evaluated using the same risk-based screens applied in Section 3. Because a secondary COPC has either never been measured in Site sediments, or was never detected, the detection frequency within the data generated by this sediment study will also be considered (to the extent possible, detection limits will be improved for this study relative to existing data). In some cases, a secondary COPC will be eliminated from further consideration in the RI because it passes the risk-based screen (Section 3). A secondary COPC will also be eliminated from further consideration in the RI if it is detected in 5 percent or less of the surface sediment samples collected from the Site for this study.

For each secondary COPC that does not pass one or more of the risk-based screens, the data generated by the sediment study will be evaluated to determine if the concentrations of the secondary COPC correlates with concentrations of the indicator chemical group, dioxins and furans. A correlation with dioxins and furans, the chemicals that are likely the primary risk drivers, will be interpreted to indicate that remedial actions to address dioxins and furans will address any relatively minor risks due to secondary COPCs. If the secondary COPC does not correlate, it will be included in the baseline risk evaluation (because it did not pass the risk-based screen). If the secondary COPC does correlate with dioxins and furans, it will not be evaluated in the baseline risk assessments.

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TABLES

Table C-1
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	Group	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
2,3,7,8-TCDD	Dioxins/Furans	1746-01-6	alpha-Chlordane[c]	Pesticide	5103-71-9
Aluminum	Metals	7429-90-5	gamma-chlordane[c]	Pesticide	5103-74-2
Antimony	Metals	7440-36-0	Endrin ketone[a]	Pesticide	53494-70-5
Arsenic	Metals	7440-38-2	Methoxychlor[a]	Pesticide	72-43-5
Barium	Metals	7440-39-3	4,4'-DDD[a]	Pesticides	72-54-8
Beryllium[a]	Metals	7440-41-7	4,4'-DDE[a]	Pesticides	72-55-9
Cadmium	Metals	7440-43-9	4,4'-DDT[a]	Pesticides	50-29-3
Chromium	Metals	7440-47-3	Aldrin[a]	Pesticides	309-00-2
Cobalt	Metals	7440-48-4	alpha-BHC[c]	Pesticides	319-84-6
Copper	Metals	7440-50-8	Endosulfan I[a]	Pesticides	959-98-8
Iron[b]	Metals	7439-89-6	beta-BHC[a]	Pesticides	319-85-7
Lead	Metals	7439-92-1	Endosulfan II[a]	Pesticides	33213-65-9
Magnesium	Metals	7439-95-4	Chlordane[a]	Pesticides	57-74-9
Manganese	Metals	7439-96-5	delta-BHC[a]	Pesticides	319-86-8
Mercury	Metals	7439-97-6	Dieldrin[a]	Pesticides	60-57-1
Nickel	Metals	7440-02-0	Endosulfan sulfate[a]	Pesticides	1031-07-8
Potassium[b]	Metals	7440-09-7	Endrin[a]	Pesticides	72-20-8
Selenium[a]	Metals	7782-49-2	Endrin aldehyde[a]	Pesticides	7421-93-4
Sodium[b]	Metals	7440-23-5	gamma-BHC (Lindane)[a]	Pesticides	58-89-9
Silver	Metals	7440-22-4	Heptachlor[a]	Pesticides	76-44-8
Thallium	Metals	7440-28-0	Heptachlor epoxide[a]	Pesticides	1024-57-3
Vanadium	Metals	7440-62-2	Toxaphene[a]	Pesticides	8001-35-2
Zinc	Metals	7440-66-6	1,2,4-Trichlorobenzene	VOC	120-82-1
Polychlorinated Biphenyls	PCBs	various	1,2-Dichlorobenzene	VOC	95-50-1
Acenaphthene	SVOC	83-32-9	1,3-Dichlorobenzene	VOC	541-73-1
Acenaphthylene[a]	SVOC	208-96-8	1,4-Dichlorobenzene	VOC	106-46-7
Anthracene[a]	SVOC	120-12-7	1,1,1-Trichloroethane	VOC	71-55-6
Benzo(a)anthracene[a]	SVOC	56-55-3	1,1,2,2-Tetrachloroethane	VOC	79-34-5
Benzo(a)pyrene[a]	SVOC	50-32-8	1,1,2-Trichloroethane [c]	VOC	79-00-5
Benzo(b)fluoranthene[a]	SVOC	205-99-2	1,1-Dichloroethane [c]	VOC	75-34-3

Table C-1
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	Group	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
Benzo(g,h,i)perylene[a]	SVOC	191-24-2	1,1-Dichloroethene [c]	VOC	75-35-4
Benzo(k)fluoranthene[a]	SVOC	207-08-9	1,2-Dichloroethane	VOC	107-06-2
Chrysene[a]	SVOC	218-01-9	1,2-Dichloropropane	VOC	78-87-5
Dibenzo(a,h)anthracene[a]	SVOC	53-70-3	trans-1,2-Dichloroethene [c]	VOC	156-60-5
Fluoranthene[a]	SVOC	206-44-0	1,2-dichloropropylene[c]	VOC	542-75-6
Fluorene	SVOC	86-73-7	2-chloroethyl vinyl ethers[c]	VOC	110-75-8
Indeno(1,2,3-cd)pyrene[a]	SVOC	193-39-5	Acrolein[c]	VOC	107-02-8
Naphthalene	SVOC	91-20-3	Acrylonitrile[c]	VOC	107-13-1
Phenanthrene	SVOC	85-01-8	Benzene	VOC	71-43-2
Pyrene[a]	SVOC	129-00-0	Bromoform[c]	VOC	75-25-2
2,4,6-Trichlorophenol	SVOC	88-06-2	Carbon tetrachloride	VOC	56-23-5
2,4-Dichlorophenol	SVOC	120-83-2	Chlorobenzene	VOC	108-90-7
2,4-Dimethylphenol[a]	SVOC	105-67-9	Chlorodibromomethane	VOC	124-48-1
2,4-Dinitrophenol[a]	SVOC	51-28-5	Chloroethane [c]	VOC	75-00-3
2-Chlorophenol	SVOC	95-57-8	Chloroform	VOC	67-66-3
2-Nitrophenol[a]	SVOC	88-75-5	Ethylbenzene	VOC	100-41-4
4-Nitrophenol[a]	SVOC	100-02-7	Bromomethane [c]	VOC	74-83-9
Pentachlorophenol	SVOC	87-86-5	Chloromethane [c]	VOC	74-87-3
Phenol	SVOC	108-95-2	Methylene chloride [c]	VOC	75-09-2
Bis(2-ethylhexyl)phthalate	SVOC	117-81-7	Tetrachloroethene	VOC	127-18-4
Butylbenzylphthalate[a]	SVOC	85-68-7	Toluene	VOC	108-88-3
Diethylphthalate[a]	SVOC	84-66-2	Trichloroethene	VOC	79-01-6
Dimethylphthalate[a]	SVOC	131-11-3	Vinyl chloride [c]	VOC	75-01-4
Di-n-butylphthalate[a]	SVOC	84-74-2	Styrene [c]	VOC	100-42-5
Di-n-octylphthalate[a]	SVOC	117-84-0	cis-1,3-Dichloropropene[c]	VOC	10061-01-5
1,2-diphenylhydrazine[a]	SVOC	122-66-7	trans-1,3-dichloropropene [c]	VOC	10061-02-6
2,4-Dinitrotoluene[a]	SVOC	121-14-2	1,2-Dibromoethane [c]	VOC	106-93-4
2,6-Dinitrotoluene[a]	SVOC	606-20-2	4-Methyl-2-pentanone [c]	VOC	108-10-1
2-Chloronaphthalene[a]	SVOC	91-58-7	Methylcyclohexane[c]	VOC	108-87-2
3,3'-Dichlorobenzidine[a]	SVOC	91-94-1	Cyclohexane [c]	VOC	110-82-7

Table C-1
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	Group	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
4,6-Dinitro-2-methylphenol[a]	SVOC	534-52-1	1,4-Dioxane [c]	VOC	123-91-1
4-Bromophenyl-phenylether[a]	SVOC	101-55-3	cis-1,2-Dichloroethene [c]	VOC	156-59-2
4-Chlorophenyl-phenyl ether[a]	SVOC	7005-72-3	Methyl tert-butyl ether [c]	VOC	1634-04-4
Benzidine[a]	SVOC	92-87-5	m,p-Xylene[c]	VOC	179601-23-1
Bis(2-chloroethoxy) methane[a]	SVOC	111-91-1	2-Hexanone [c]	VOC	591-78-6
Bis(2-chloroethyl)ether[a]	SVOC	111-44-4	Acetone [c]	VOC	67-64-1
Bis(2-chloroisopropyl) ether[a]	SVOC	39638-32-9	Bromochloromethane [c]	VOC	74-97-5
Hexachlorobenzene	SVOC	118-74-1	Carbon disulfide [c]	VOC	75-15-0
Hexachlorobutadiene[a]	SVOC	87-68-3	Trichlorofluoromethane [c]	VOC	75-69-4
Hexachlorocyclo-pentadiene[a]	SVOC	77-47-4	Dichlorodifluoromethane [c]	VOC	75-71-8
Hexachloroethane[a]	SVOC	67-72-1	1,1,2-Trichloro-1,2,2-trifluoroethane [c]	VOC	76-13-1
Isophorone[a]	SVOC	78-59-1	2-Butanone [c]	VOC	78-93-3
Nitrobenzene[a]	SVOC	98-95-3	Methyl acetate [c]	VOC	79-20-9
N-nitrosodimethylamine[a]	SVOC	62-75-9	1,2,3-Trichlorobenzene	VOC	87-61-6
N-Nitroso-di-n propylamine[a]	SVOC	621-64-7	o-Xylene [c]	VOC	95-47-6
N-Nitrosodiphenylamine[a]	SVOC	86-30-6	1,2-Dibromo-3-chloropropane [c]	VOC	96-12-8
4-Chloro-3-methylphenol[a]	SVOC	59-50-7	Isopropylbenzene [c]	VOC	98-82-8
4-Nitroaniline[a]	SVOC	100-01-6	Cyanide, Total[c]	Conventionals	57-12-5
Benzaldehyde[a]	SVOC	100-52-7			
Caprolactam[a]	SVOC	105-60-2			
4-Methylphenol	SVOC	106-44-5			
4-Chloroaniline[a]	SVOC	106-47-8			
2,2'-Oxybis(1-chloropropane)[a]	SVOC	108-60-1			
Dibenzofuran[a]	SVOC	132-64-9			
Atrazine[c]	SVOC	1912-24-9			
2,3,4,6-Tetrachlorophenol	SVOC	58-90-2			
Carbazole	SVOC	86-74-8			
2-Nitroaniline[a]	SVOC	88-74-4			
2-Methylnaphthalene[a]	SVOC	91-57-6			
1,1'-Biphenyl[a]	SVOC	92-52-4			

Table C-1
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	Group	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
2-Methylphenol	SVOC	95-48-7			
1,2,4,5-Tetrachlorobenzene	SVOC	95-94-3			
2,4,5-Trichlorophenol	SVOC	95-95-4			
Acetophenone[a]	SVOC	98-86-2			
3-Nitroaniline[a]	SVOC	99-09-2			

Notes

CLP = Contract Laboratory Program
TAL = target analyte list
VOC = volatile organic compound
COI = contaminant of interest
a - Chemical is not associated with pulp mill waste and was never detected in Site sediments, so is not moved forward for evaluation as a COI.
b - Chemical is an essential nutrient and is not moved forward for evaluation as a as a COI.
c - Chemical is not associated with pulp mill waste and was never analyzed for in Site sediments, so is not moved forward as a COI.

Table C-2
Chemicals of Interest

Class	Chemical
Dioxins/Furans	
	Dioxins and Furans
Metals	
	Aluminum
	Antimony
	Arsenic
	Barium
	Cadmium
	Chromium
	Cobalt
	Copper
	Lead
	Magnesium
	Manganese
	Mercury
	Nickel
	Silver
	Thallium
	Vanadium
	Zinc
Polychlorinated Biphenyls (PCBs)	
	Polychlorinated Biphenyls
Semivolatile Organic Compounds (SVOCs)	
	Acenaphthene
	Fluorene
	Naphthalene
	Phenanthrene
	2,4,6-Trichlorophenol
	2,4-Dichlorophenol
	Pentachlorophenol
	Phenol
	Hexachlorobenzene

Chemicals of Interest

Class	Chemical
	2,3,4,6-Tetrachlorophenol
	Carbazole
	2,4,5-Trichlorophenol
	Bis(2-ethylhexyl)phthalate
Volatile Organic Compounds (VOCs)	
	Chloroform
	1,2,4-Trichlorobenzene
	1,2-Dichlorobenzene
	1,3-Dichlorobenzene
	1,4-Dichlorobenzene
	1,2,3-Trichlorobenzene

Table C-3
Chemicals Potentially Associated with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Generally in Bleached Pulp Mill Waste (Wiegand 2010)	Effluents (Suntio et al. 1998)	Solid Wastes (NCASI 1999)	Leachates (NCASI 1992)	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
Dioxins/Furans					
Dioxins and Furans	X	X	X		X
Metals					
Aluminum			X	X	X
Antimony					
Arsenic			X	X	X
Barium			X	X	X
Cadmium			X		X
Chromium			X		X
Cobalt			X		X
Copper			X	X	X
Lead			X	X	X
Magnesium			X	X	X
Manganese			X	X	X
Mercury	X		X	X	X
Nickel			X		X
Silver					
Thallium				X	X
Vanadium					
Zinc			X	X	X
Polychlorinated Biphenyls (PCBs)					
Polychlorinated Biphenyls			X		X
Semivolatile Organic Compounds (SVOCs)					
Acenaphthene			X		X
Fluorene			X		X
Naphthalene			X		X
Phenanthrene			X		X
2,4,6-Trichlorophenol	X	X	X	X	X
2,4-Dichlorophenol	X	X	X		X
2-Chlorophenol	X	X		X	X
Pentachlorophenol	X	X		X	X
Phenol			X		X
Hexachlorobenzene		X			X
4-Methylphenol				X	X

Table C-3
Chemicals Potentially Associated with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Generally in Bleached Pulp Mill Waste (Wiegand 2010)	Effluents (Suntio et al. 1998)	Solid Wastes (NCASI 1999)	Leachates (NCASI 1992)	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
2,3,4,6-Tetrachlorophenol	X	X		X	X
Carbazole			X		X
2-Methylphenol				X	X
2,4,5-Trichlorophenol	X	X	X	X	X
Bis(2-ethylhexyl)phthalate				X	X
1,2,4,5-Tetrachlorobenzene		X			X
Volatile Organic Compounds (VOCs)					
1,2,4-Trichlorobenzene		X			X
1,2-Dichlorobenzene		X			X
1,3-Dichlorobenzene		X			X
1,4-Dichlorobenzene		X			X
1,1,1-Trichloroethane		X			X
1,1,2,2-Tetrachloroethane		X			X
1,2-Dichloroethane		X			X
Benzene		X			X
Carbon tetrachloride		X			X
Chlorobenzene		X			X
Chloroform		X	X		X
Ethylbenzene		X			X
Tetrachloroethene		X			X
Toluene		X	X	X	X
Trichloroethene		X			X
1,2-Dichloropropane		X			X
Chlorodibromomethane		X			X
1,2,3-Trichlorobenzene		X			X

Notes

For chemicals not associated with pulp mill waste and never analyzed or analzyed and never detected, see Table 4.
CLP = Contract Laboratory Program
COI = chemical of interest
CWA PPL = Clean Water Act priority pollutant list
TAL = target analyte list
X = yes

Table C-4
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence, and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Association with Pulp Mill Waste								
	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Generally in Bleached Pulp Mill Waste (Wiegand 2010)	Effluents (Suntio et al. 1988)	Solid Wastes (NCASI 1999)	Leachates (NCASI 1992)	Chemicals Potentially Associated with Pulp Mill Waste[a]	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment[b]	COI
Dioxins and Furans	X	X	X	X	X		X	X	X
Metals									
Aluminum	X	X			X	X	X	NA	X
Antimony	X	X						NA	X
Arsenic	X	X			X	X	X	NA	X
Barium	X	X			X	X	X	NA	X
Cadmium	X	X			X		X	NA	X
Chromium	X	X			X		X	NA	X
Cobalt	X	X			X		X	NA	X
Copper	X	X			X	X	X	NA	X
Lead	X	X			X	X	X	NA	X
Magnesium	X	X			X	X	X	NA	X
Manganese	X	X			X	X	X	NA	X
Mercury	X	X	X		X	X	X	NA	X
Nickel	X	X			X		X	NA	X
Silver	X	X						NA	X
Thallium	X					X	X	NA	X
Vanadium	X	X						NA	X
Zinc	X	X			X	X	X	NA	X
Polychlorinated Biphenyls (PCBs)	X				X		X	X	X
Semivolatile Organic Compounds (SVOCs)									
Acenaphthene	X				X		X	X	X
Fluorene	X				X		X	X	X
Naphthalene	X				X		X	X	X
Phenanthrene	X				X		X	X	X
2,4,6-Trichlorophenol	X		X	X	X	X	X	X	X
2,4-Dichlorophenol	X		X	X	X		X	X	X
2-Chlorophenol	X		X	X	X		X		
Pentachlorophenol	X		X	X		X	X	X	X
Phenol	X				X	X	X	X	X
Hexachlorobenzene	X			X			X	X	X
4-Methylphenol	X					X	X		
2,3,4,6-Tetrachlorophenol			X	X		X	X	X	X
Carbazole					X		X	X	X
2-Methylphenol	X					X	X		
2,4,5-Trichlorophenol	X		X	X	X	X	X	X	X

Table C-4
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence, and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Association with Pulp Mill Waste: Generally in Bleached Pulp Mill Waste (Wiegand 2010)	Effluents (Suntio et al. 1988)	Solid Wastes (NCASI 1999)	Leachates (NCASI 1992)	Chemicals Potentially Associated with Pulp Mill Waste[a]	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment[b]	COI
Bis(2-ethylhexyl)phthalate	X	X				X	X	X	X
1,2,4,5-Tetrachlorobenzene	X			X			X		
Volatile Organic Compounds (VOCs)									
1,2,4-Trichlorobenzene				X			X	X	X
1,2-Dichlorobenzene				X			X	X	X
1,3-Dichlorobenzene				X			X	X	X
1,4-Dichlorobenzene				X			X	X	X
1,1,1-Trichloroethane				X			X		
1,1,2,2-Tetrachloroethane				X			X		
1,2-Dichloroethane				X			X		
Benzene				X			X		
Carbon tetrachloride				X			X		
Chlorobenzene				X			X		
Chloroform				X	X		X	X	X
Ethylbenzene				X			X		
Tetrachloroethene				X			X		
Toluene				X	X	X	X		
Trichloroethene				X			X		
1,2-Dichloropropane				X			X		
Chlorodibromomethane				X			X		
1,2,3-Trichlorobenzene				X			X	X	X

Notes

For chemicals not associated with pulp mill waste and never analyzed or analzyed and never detected, see Table 4.
CLP = Contract Laboratory Program
COI = chemical of interest
CWA PPL = Clean Water Act priority pollutant list
Koc = partition coefficient of a chemical in the organic matter of soil/sediment
NA = not applicable
TAL = target analyte list
X = yes
a - See Table 6
b - Persistence based on evaluation provided in NIH (2010): Chemicals were classified as "persistent" if the Koc value indicated that the chemical was likely to adsorb to suspended solid and sediment. Chemicals were classified as "not persistent" if the Koc value indicated that the chemical may adsorb or was not likely to adsorb to suspended solid and sediment. No additional metrics were used to determine persistence since half-life durations for volatilization from water or biodegradation were very short in comparison to the 44 years that have elapsed since the chemicals were deposited in the impoundment.

Table C-5
Summary of Primary and Secondary COPCs

COIs	BHHRA		BERA			
			Benthic Invertebrates		Fish and Wildlife	
	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC
Dioxins/Furans						
Dioxins and Furans	X				X	
Metals						
Aluminum			X			
Antimony						
Arsenic	X					
Barium			X			
Cadmium	X				X	
Chromium	X					
Cobalt			X			
Copper	X		X		X	
Lead			X			
Magnesium			X			
Manganese			X			
Mercury	X		X		X	
Nickel	X				X	
Silver						
Thallium				X		
Vanadium			X			
Zinc	X		X		X	
Polychlorinated Biphenyls (PCBs)						
Polychlorinated Biphenyls		X				X
Semivolatile Organic Compounds (SVOCs)						
Acenaphthene				X		
Fluorene				X		
Naphthalene				X		
Phenanthrene				X		
2,4,6-Trichlorophenol				X		
2,4-Dichlorophenol				X		
Pentachlorophenol		X		X		X

Table C-5
Summary of Primary and Secondary COPCs

COIs	BHHRA		BERA			
			Benthic Invertebrates		Fish and Wildlife	
	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC
Phenol				X		
Hexachlorobenzene		X		X		X
2,3,4,6-Tetrachlorophenol		X		X		
Carbazole				X		
2,4,5-Trichlorophenol				X		
Bis(2-ethylhexyl)phthalate	X		X		X	
Volatile Organic Compounds (VOCs)						
1,2,4-Trichlorobenzene		X		X		
1,2-Dichlorobenzene		X		X		
1,3-Dichlorobenzene		X		X		
1,4-Dichlorobenzene		X		X		
Chloroform		X		X		
1,2,3-Trichlorobenzene		X		X		

Notes

BERA = baseline ecological risk assessment
BHHRA = baseline human health risk assessment
COI = chemical of interest
COPC = chemical of potential concern
X = yes

Table C-6
COPC Screening for Human Health

	Highest Site Concentration[a]	Frequency of Detection of Site Samples	USEPA Region 3 Soil PRG[b]	$^{Tot}Sed_{Comb}$ [c]	Does Maximum Site Value Exceed PRG or $^{Tot}Sed_{Comb}$?	Is Chemical Potentially Bioaccumulative from Sediment?	Is Chemical Detected at Least Once in Site Sediments?	Maintain as COPC for Human Health?	Revised Reason for COPC Decision, Excluding Background Consideration
Metals (mg/kg)									
Aluminum	22,100	7/7	77,000	150,000	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Antimony	7.2 *U*	1/7	31	83	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Arsenic	3	4/7	0.39	110	Yes	No	Yes	Primary	Exceeds SLV, detected at least once in Site sediments
Barium	244	7/7	15,000	23,000	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Cadmium	0.7 *U*	4/7	70	1,100	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Chromium	22.1	7/7	0.29/120,000	140/36,000 (VI / III)	Yes	No	Yes	Primary	Exceeds SLV, detected at least once in Site sediments
Cobalt	6.8 *J*	7/7	23	32,000	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Copper	62.5	7/7	3,100	21,000	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Lead	59.3	7/7	400	500	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Magnesium	4790	7/7	NV	NV	NV	No	Yes	No	No SLV, not potentially bioaccumulative
Manganese	790	7/7	1,800	14,000	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Mercury	1.7	7/7	24	34	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Nickel	14	7/7	1,600	1,400	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Silver	1.4 *U*	2/7	390	350	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Thallium	3.5 *U*	0/7	NV	43	No	No	No	No	No SLV, never detected in Site Sediments
Vanadium	34.4	7/7	390	330	No	No	Yes	No	Does not exceed SLV and is not potentially bioaccumulative
Zinc	244	7/7	24,000	76,000	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Polychlorinated Biphenyls (µg/kg)									
Total PCBs	90 *U*	0/7	220	2,300	No	Yes	No	Secondary	Potentially bioaccumulative, never detected in Site sediments
Dioxins/Furans (ng/kg)									
2,3,7,8-TCDD TEQ	24,000	7/7	4.9	1,000	Yes	Yes	Yes	Primary	Exceeds PRG, detected at least once in Site sediments
Semivolatile Organic Compounds (µg/kg)									
Acenaphthene	455 *U*	0/7	3,400,000	7,400,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Fluorene	455 *U*	0/7	2,300,000	4,900,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Naphthalene	455 *U*	0/7	3600	2,500,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Phenanthrene	455 *U*	0/7	NV	3,700,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
2,4,6-Trichlorophenol	455 *U*	0/7	44,000	1,300,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
2,4-Dichlorophenol	455 *U*	0/7	180,000	460,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Pentachlorophenol	1,150 *U*	0/7	3,000	56,000	No	Yes	No	Secondary	No SLV; potentially bioaccumulative, never detected
Phenol	455 *U*	0/7	18,000,000	46,000,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Hexachlorobenzene	455 *U*	0/7	300	8,900	Yes	Yes	No	Secondary	Exceeds SLV and has potential to bioaccumulate
2,3,4,6-Tetrachlorophenol	NV	NV	1,800,000	4,600,000	NV	No	NV	Secondary	No information available on which to base evaluation
Carbazole	455 *U*	0/7	NV	710,000	No	No	No	No	No SLV, not potentially bioaccumulative
2,4,5-Trichlorophenol	1,150 *U*	0/7	6,100,000	15,000,000	No	No	No	No	Does not exceed SLV and is not potentially bioaccumulative
Bis(2-ethylhexyl)phthalate	1800	3/7	35,000	240,000	No	Yes	Yes	Primary	Potentially bioaccumulative, detected at least once in Site sediments
Volatile Organic Compounds (µg/kg)									
Chloroform	NV	not analyzed	290	7,300,000	NV	No	NV	Secondary	No information available on which to base evaluation
1,2,4-Trichlorobenzene	NV	not analyzed	22,000	1,500,000	NV	No	NV	Secondary	No information available on which to base evaluation
1,2-Dichlorobenzene	NV	not analyzed	1,900,000	66,000,000	NV	No	NV	Secondary	No information available on which to base evaluation
1,3-Dichlorobenzene	NV	not analyzed	NV	22,000,000	NV	No	NV	Secondary	No information available on which to base evaluation
1,4-Dichlorobenzene	NV	not analyzed	2400	2,300,000	NV	No	NV	Secondary	No information available on which to base evaluation
1,2,3-Trichlorobenzene	NV	not analyzed	49,000	460,000	NV	No	NV	Secondary	No information available on which to base evaluation

Notes

COPC = chemical of potential concern
NV = no value available
PRG = preliminary remediation goal
TEQ = toxicity equivalent
J = estimated
U = analyte not detected

Table C-6
COPC Screening for Human Health

	Highest Site Concentration[a]	Frequency of Detection of Site Samples	USEPA Region 3 Soil PRG[b]	$^{Tot}Sed_{Comb}$[c]	Does Maximum Site Value Exceed PRG or $^{Tot}Sed_{Comb}$?	Is Chemical Potentially Bioaccumulative from Sediment?	Is Chemical Detected at Least Once in Site Sediments?	Maintain as COPC for Human Health?	Revised Reason for COPC Decision, Excluding Background Consideration

a - Nondetects are provided at 1/2 the detection limit.
b - PRGs are from http://www.epa.gov/reg3hwmd/risk/human/index.htm.
c - TotSedComb values are from TCEQ (2006) Tier 1 Sediment PCLs.

Table C-7
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006) [b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
Metals (mg/kg)						
Aluminum	NV	22,100	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Antimony	NV	7.2 *U*	1/7	NSLV	No	No SLV; however, there is only a single detection in Site data and this is not a chemical expected to be associated with pulp mill waste
Arsenic	8.2	3	4/7	No	No	Maximum site concentration does not exceed SLV
Barium	NV	244	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Cadmium	1.2	0.7 *U*	4/7	No	No	Maximum site concentration does not exceed SLV
Chromium	81	22.1	7/7	No	No	Maximum site concentration does not exceed SLV
Cobalt	NV	6.8 *J*	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Copper	34	62.5	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Lead	46.7	59.3	7/7	No	Yes	Maximum site concentration exceeds SLV
Magnesium	NV	4,790	7/7	NSLV	Yes	No screening value, detected at least once in Site sediments
Manganese	NV	790	7/7	NSLV	Yes	No screening value, detected at least once in Site sediments
Mercury	0.15	1.7	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Nickel	20.9	14	7/7	No	No	Maximum site concentration does not exceed SLV
Silver	1	1.4 *U*	2/7	Yes	No	Highest concentration is close to SLV. High percentage of non-detects. Highest detected concentration is 0.29, below SLV
Thallium	NV	3.5 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Vanadium	NV	34.4	7/7	NSLV	Yes	No SLV, detected at least once in Site sediments
Zinc	150	244	7/7	Yes	Yes	Maximum site concentration exceeds SLV
Dioxins/Furans (ng/kg)						
2,3,7,8-TCDD	25,000[e]	18,500	7/7	No	No	Maximum site value does not exceed SLV
Polychlorinated Biphenyls (PCBs) (µg/kg)						
Total PCBs	1,200[f]	90 *U* [g]	0/7	N/A	No	Highest detection limit does not exceed screening value
Semivolatile Organic Compounds (µg/kg)						
Acenaphthene	16	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Fluorene	19	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Naphthalene	160	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Phenanthrene	240	455 *U*	0/7	Yes	Yes (secondary)	No SLV, no detected concentrations in Site sediments
2,4,6-Trichlorophenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
2,4-Dichlorophenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Pentachlorophenol	NV	1,150 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Phenol	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments
Hexachlorobenzene	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations in Site sediments

Table C-7
COPC Screening for Benthic Macroinvertebrate Community

Chemical	NOEC [a]	Highest Site Concentration (TCEQ and USEPA 2006) [b]	Frequency of Detection of Site Samples	Does Maximum Site Sample Exceed NOEC?	Maintain as COPC for Benthic Invertebrates?	Reason for COPC Decision
2,3,4,6-Tetrachlorophenol	NV	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
Carbazole	NV	455 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations
2,4,5-Trichlorophenol	NV	1,150 *U*	0/7	NSLV	Yes (secondary)	No SLV, no detected concentrations
Bis(2-ethylhexyl)phthalate	182	1800	3/7	Yes	Yes	Maximum site concentration exceeds SLV
Volatile Organic Compounds (µg/kg)						
Chloroform	4300[h]	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2,4-Trichlorobenzene	390	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2-Dichlorobenzene	740	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,3-Dichlorobenzene	320	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,4-Dichlorobenzene	700	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation
1,2,3-Trichlorobenzene	NV	NV	NV	NA	Yes (secondary)	No information available on which to base evaluation

Notes

DL = detection limit
EqP = equilibrium partitioning
OC = organic carbon
NA = not applicable
NOEC = no effect concentration
NV = no value
NSLV = no screening level value available
SLV = screening level value
J = estimated
U = analyte not detected

a - NOEC (no effect concentration) is from TCEQ 2006 and is based on Long et al. (1995) unless otherwise indicated. Units of screening value match those of sediment data as given in compound class header (e.g., metals in mg/kg).
b - Nondetects are provided at 1/2 the detection limit.
d - Comparison is uncertain because there is a high percentage of non-detects for chemical at site and a maximum detection limit is being used.
e - Barber et al. (1998)
f - Fuchsman et al. (2006). Lowest unbounded NOEC (growth) for a PCB mixture of 81 mg/kg OC (*Macoma nasuta*). Using EqP and conservative estimate of organic carbon of 1.5 percent (Louchouarn and Brinkmeyer 2009), the dry weight equivalent of this value is 1.2 mg/kg.
g - As there were no detections of PCBs, this value is the highest reporting limit in the data set for PCBs.
h - Table 3-3 in TCEQ (2006).

Table C-8
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Metals (mg/kg)						
Aluminum	22,100	7/7	NA	No	No	Not potentially bioaccumulative
Antimony	7.2 *U*	1/7	NA	No	No	Not potentially bioaccumulative
Arsenic	3	7/7	NA	No	No	Not potentially bioaccumulative
Barium	244	7/7	NA	No	No	Not potentially bioaccumulative
Cadmium	0.7 *U*	4/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Chromium	22.1	7/7	NA	No	No	Not potentially bioaccumulative
Cobalt	6.8 *J*	7/7	NA	No	No	Not potentially bioaccumulative
Copper	62.5	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Lead	59.3	7/7	NA	No	No	Not potentially bioaccumulative
Magnesium	4,790	7/7	NA	No	No	Not potentially bioaccumulative
Manganese	790	7/7	NA	No	No	Not potentially bioaccumulative
Mercury	1.7	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Nickel	14	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Silver	1.4 *U*	2/7	NA	No	No	Not potentially bioaccumulative
Thallium	3.5 *U*	0/7	NA	No	No	Not potentially bioaccumulative
Vanadium	34.4	7/7	NA	No	No	Not potentially bioaccumulative
Zinc	244	7/7	NA	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Dioxins/Furans (ng/kg)						
TEQ birds at ND=1/2DL	62,200	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
TEQ fish at ND=1/2DL	22,300	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
TEQ mammals at ND=1/2 DL	24,000	N/A	>5	Yes	Yes	Potentially bioaccumulative, detected at least once in Site sediments
Polychlorinated Biphenyls (µg/kg)						
Total PCBs	90 U[d]	0/7	>5	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
Semivolatile Organic Compounds (µg/kg)						
Acenaphthene	455 *U*	0/7	3.92	No[e]	No	Not potentially bioaccumulative
Fluorene	455 *U*	0/7	4.18	No[e]	No	Not potentially bioaccumulative
Naphthalene	455 *U*	0/7	3.3	No[e]	No	Not potentially bioaccumulative
Phenanthrene	455 *U*	0/7	4.57	No[e]	No	Not potentially bioaccumulative
2,4,6-Trichlorophenol	455 *U*	0/7	3.72	No[e]	No	Not potentially bioaccumulative
2,4-Dichlorophenol	455 *U*	0/7	3.06	No[e]	No	Not potentially bioaccumulative
Pentachlorophenol	1,150 *U*	0/7	5.12	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
Phenol	455 *U*	0/7	1.46	No[f]	No	Not potentially bioaccumulative
Hexachlorobenzene	455 *U*	0/7	5.73	Yes	Yes (secondary)	Potentially bioaccumulative, no detected concentrations in Site sediments
2,3,4,6-Tetrachlorophenol	NV	NV	4.45	No[e]	No	Not potentially bioaccumulative

Table C-8
COPC Screening for Fish and Wildlife

Chemical	Highest Site Concentration (TCEQ and USEPA 2006)[a]	Frequency of Detection of Site Samples	Log Kow of Chemical (Organics Only)[b]	Is Chemical Potentially Bioaccumulative from Sediment?[c]	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Carbazole	455 *U*	0/7	3.72	No[e]	No	Not potentially bioaccumulative
2,4,5-Trichlorophenol	1,150 *U*	0/7	3.69	No[e]	No	Not potentially bioaccumulative
Bis(2-ethylhexyl)phthalate	1800	3/7	7.6	Yes	Yes	Potentially bioaccumulative, detected in Site sediments
Volatile Organic Compounds (µg/kg)						
Chloroform	NV	NV	1.97	No[e]	No	Not potentially bioaccumulative
1,2,4-Trichlorobenzene	NV	NV	4.02	No[e]	No	Not potentially bioaccumulative
1,2-Dichlorobenzene	NV	NV	3.43	No[e]	No	Not potentially bioaccumulative
1,3-Dichlorobenzene	NV	NV	3.53	No[e]	No	Not potentially bioaccumulative
1,4-Dichlorobenzene	NV	NV	3.44	No[e]	No	Not potentially bioaccumulative
1,2,3-Trichlorobenzene	NV	NV	4.05	No[e]	No	Not potentially bioaccumulative

Notes

COPC = chemical of potential concern
NA = not applicable
NV = no value
TCEQ = Texas Commission on Environmental Quality
TEQ = toxicity equivalent
J = estimated
U = analyte not detected

a - Undetected values are set to 1/2 the detection limit.

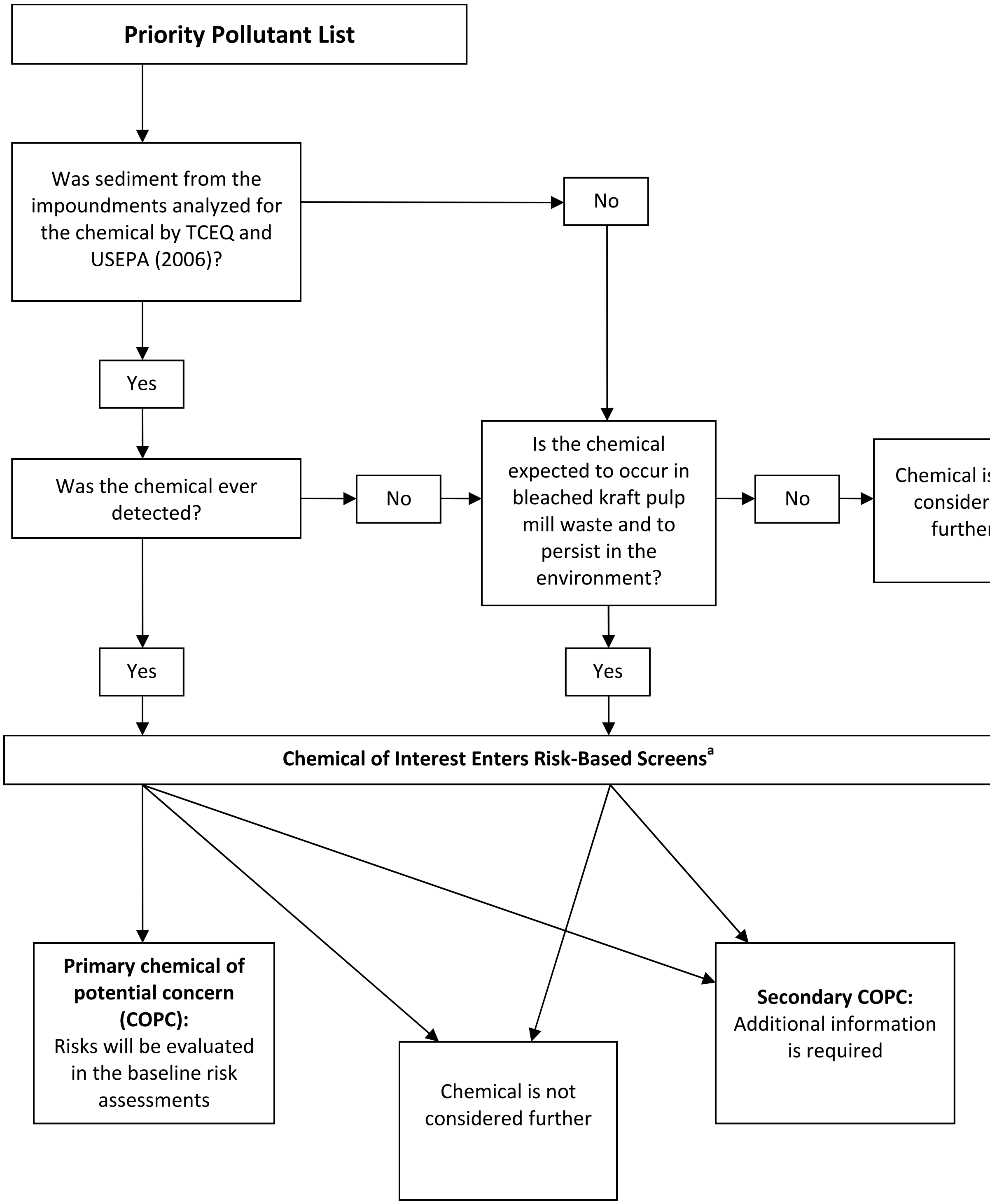
b - Log Kow: Octanol-water partition coefficient, the ratio of the concentration of a chemical in octanol and water at equilibrium and at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter (e.g., lipids). Values obtained from the HSDB (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB) or Oak Ridge National Laboratory Risk Assessment Information System (http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=chem)

c - Determination of bioaccumulative potential is based on TCEQ guidance (TCEQ 2006) or, if chemical is not addressed in guidance, log Kow information is used to determine bioaccumulative potential (as indicated in footnote e), with those chemicals having log Kow>5 being considered potentially bioaccumulative (USEPA 2008).

d - As there were no detections of PCBs, this value is the highest reporting limit in the dataset for PCBs+A66.

e - Not provided in TCEQ guidance; log Kow used to determine potential for bioaccumulation as described in footnote d.

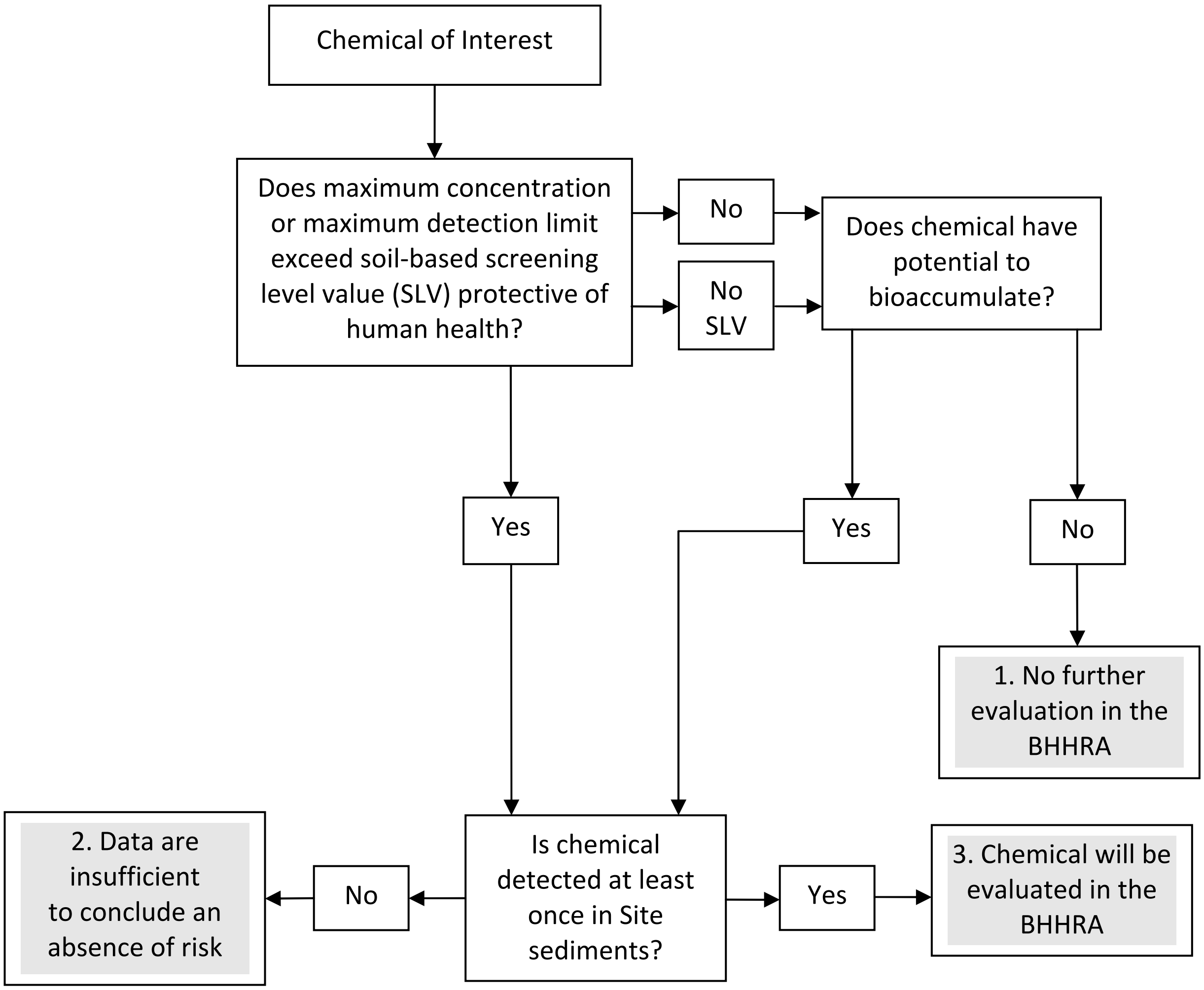
FIGURES



[a]**Chemicals of Interest** are those that will enter the risk-based screening process. Three separate risk-based screens will be used: a) fish and wildlife, b) benthic invertebrates, and c) human health.

Figure C-1
Identification of COIs at the Site
SJRWP Draft Selection of COPCs
SJRWP Superfund/MIMC and IPC

DRAFT

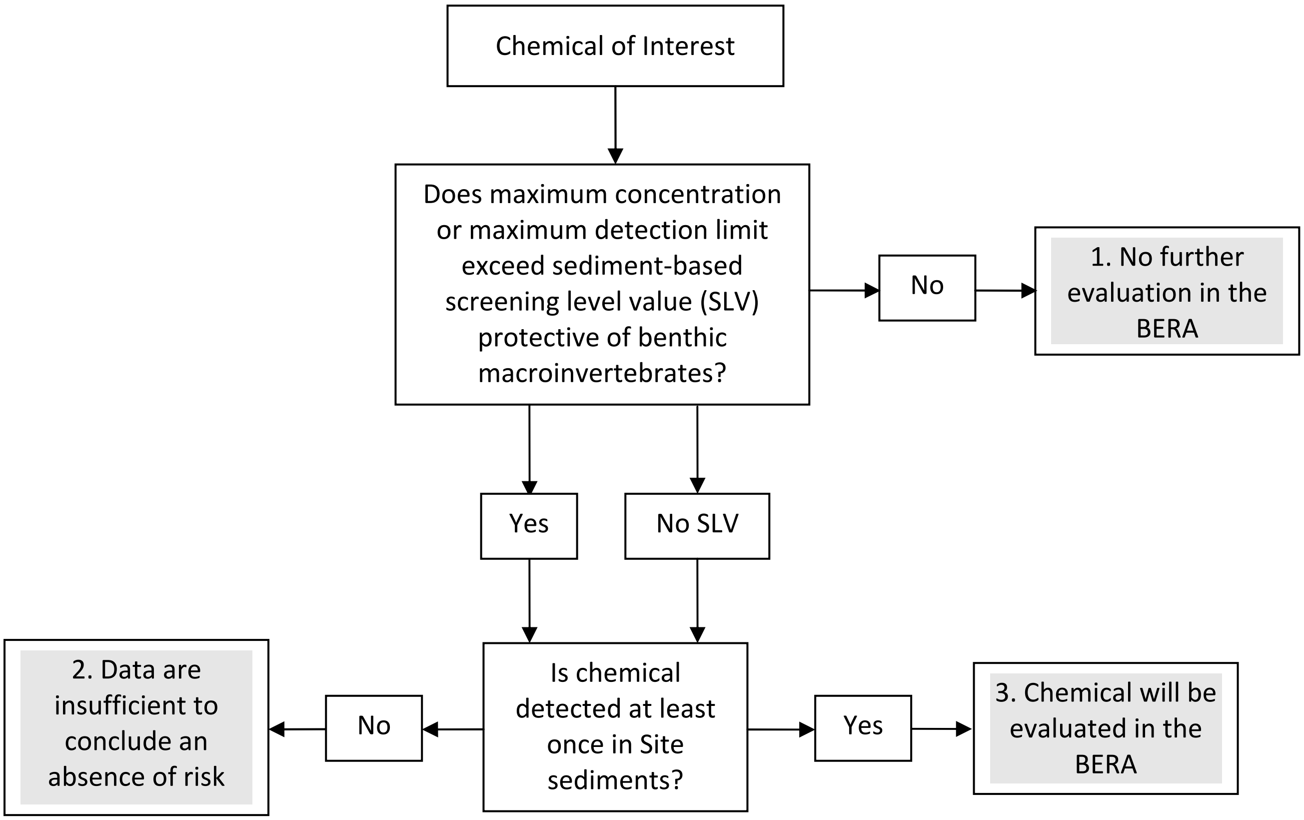


Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to human health. **Chemical will not be evaluated further in the baseline human health risk assessment (BHHRA)**.
2. Data are insufficient to conclude an absence of risk to human health. **Chemical is retained as a secondary chemical of potential concern (COPC)**.
3. Data are sufficient to conclude that the chemical must be evaluated in the BHHRA. **Chemical is retained as a primary COPC.**

DRAFT

Figure C-2
Process for COI Screening Evaluation of Risk to Human Health
SJRWP Draft Selection of COPCs
SJRWP Superfund/MIMC and IPC

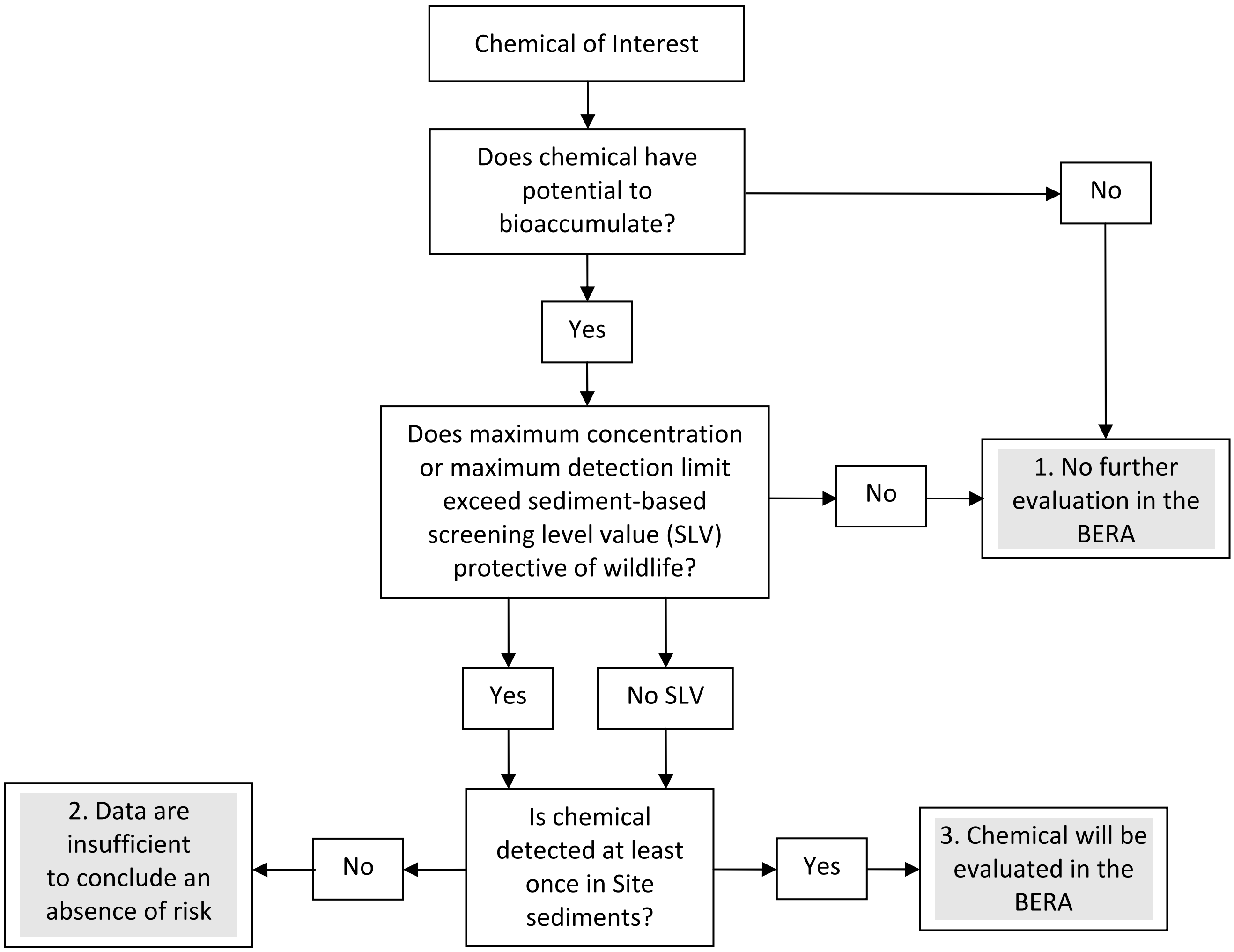


Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to benthic macroinvertebrates. **Chemical will not be evaluated further in the baseline ecological risk assessment (BERA)**.
2. Data are insufficient to conclude an absence of risk to benthic macroinvertebrates. **Chemical is retained as a secondary chemical of potential concern (COPC)**.
3. Data are sufficient to conclude that the chemical must be evaluated in the BERA. **Chemical is retained as a primary COPC.**

Figure C-3
Process for Screening Evaluation of Risk to Benthic Macroinvertebrates
SJRWP Draft Selection of COPCs
SJRWP Superfund/MIMC and IPC

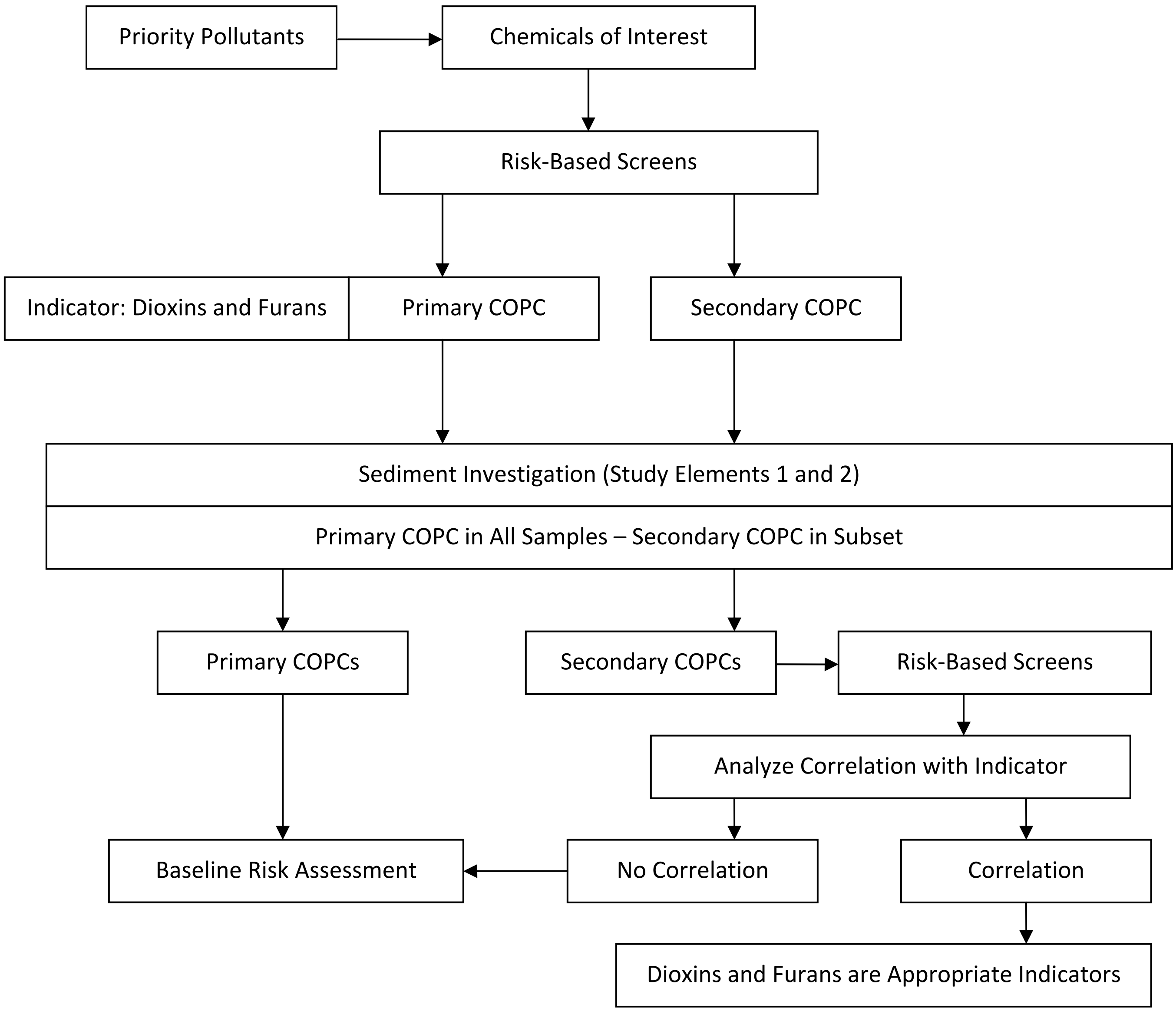
DRAFT



Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to fish and wildlife. **Chemical will not be evaluated further in the baseline ecological risk assessment (BERA)**.
2. Data are insufficient to conclude an absence of risk to fish and wildlife. **Chemical is retained as a secondary chemical of potential concern (COPC)**.
3. Data are sufficient to conclude that the chemical must be evaluated in the BERA. **Chemical is retained as a primary COPC.**

Figure C-4
Process for Screening Evaluation of Risk to Fish and Wildlife
SJRWP Draft Selection of COPCs
SJRWP Superfund/MIMC and IPC



COPC – chemical of potential concern

Figure C-5
COPC Selection and Analysis Process
SJRWP Draft Selection of COPCs
SJRWP Superfund/MIMC and IPC

APPENDIX D

DRAFT DATA QUALITY AND USABILITY ASSESSMENT CHECKLISTS

Appendix D-1
Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	204.2	Antimony
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	206.2	Arsenic
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	210.2	Beryllium
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	213.2	Cadmium
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	218.1	Chromium (III)
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	220.2	Copper
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	236.2	Iron
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	239.2	Lead
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	245.1	Mercury
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	249.2	Nickel
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	270.2	Selenium
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	272.2	Silver
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	279.2	Thallium
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	289.2	Zinc
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	TAMU-GERG	Organo-tin
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	8290	Dioxin/furans
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	TAMU-TERL	Acid volatile sulfide
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	TAMU-TERL	Aqueous volatile metals
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	8240	VOCs
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix B, which is not included in this document.		No QA info included in report.	8270	SVOCs

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Independent Data Validation Performed?	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	Texas A&M University, Geotechnical and Environmental Research Group (GERG)	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	Triangle Laboratories	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	Texas A&M, Trace Element Research Laboratory (TERL)	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	Texas A&M, Trace Element Research Laboratory (TERL)	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	Sediment	PDP Analytical Services	NA	NA

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	NA	NA	Yes	NA	B. Lawrence

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	Cat 2			No QA info included in report.	NA	Dioxin/furans
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	Cat 2			No QA info included in report.	WHO 2005	Total TEQ
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Cat 1	Zinc qualified due to serial dilution results.			CLP SOW ILM05.3	Metals
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Cat 1	All data acceptable; a few data points were qualified due to analyte concentrations exceeding the calibration range of the instrument.			CLP SOW DLM01.4	Dioxin/furans
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Cat 1				CLP SOW OLM04.3	SVOCs, pesticides, and PCBs
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Total solids
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Grain size
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	TOC
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	VOCs
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Total solids
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	TOC
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_RunoffW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Total solids
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Grain size
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	TOC

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Independent Data Validation Performed?	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	NA	NA	Soil	ALS Laboratory Group	NA	NA
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	NA	NA	Soil	ALS Laboratory Group	NA	NA
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Yes, Lockheed Martin Services Group	Stage 2B	Sediment	Bonner	Yes	Acceptable
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Yes, Lockheed Martin Services Group	Stage 2B	Sediment	Paradigm	Yes	Acceptable
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Yes, Lockheed Martin Services Group	Stage 2B	Sediment	A4 Scientific	Yes	Acceptable
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sediment	Pace/PSC	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sludge	NA	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	Sludge	NA	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_RunoffW07	NA	NA	Sediment	Pace/PSC	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	Sediment	Pace	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	Sediment	NWDLS	NA	NA

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	Yes	NA	NA	Yes	Yes	M. Tanner
Orion 2009	Corps Special Permit Report 174513 (Sneed Shipbuilding)	Orion2009	Yes	NA	NA	Yes	Yes	M. Tanner
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Acceptable, some sample results were qualified due to blank results.	Antimony results qualified due to low MS recovery (post-digestion recovery was acceptable).	Below QC limit for barium; barium results qualified.	Acceptable	No	M. Tanner/K. Carlton
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	M. Tanner/K. Carlton
TCEQ and EPA 2006	Screening Site Inspection Report, San Jacinto River Waste Pits, Channelview, Harris County, Texas	TCEQ_2006	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	K. Carlton
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	No	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_RunoffW07	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	NA	NA	No	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	NA	NA	NA	C. Hutchings

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Volatile solids
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Sediment Core Database	db_SedCore	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	1613B	Dioxins/furans
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	160.4	Volatile solids
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	160.3	Total solids
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	415.2	TOC
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Cat 1				EPA 8280	Dioxin
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Cat 1				EPA 8290	Dioxin
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F, which is not included in this document.		No QA info included in report.	SW6020 and SW7471	Metals
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F, which is not included in this document.		No QA info included in report.	SW8270	SVOCs
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F which is not included in this document.		No QA info included in report.	SW8082	PCBs

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Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Independent Data Validation Performed?	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	Sediment	NWDLS	NA	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Sediment Core Database	db_SedCore	NA	NA	Sediment	NA	NA	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Data review conducted, although not verified as independent.	NA	Sediment, sludge	Pace	NA	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Data review conducted, although not verified as independent.	NA	Sediment, sludge	NWDLS	NA	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Data review conducted, although not verified as independent.	NA	Sediment, sludge	NWDLS	NA	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Data review conducted, although not verified as independent.	NA	Sediment, sludge	NWDLS	NA	NA
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Yes, URS	Stage 2B	Sediment	Pace	Yes	Yes, OK.
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Yes, URS	Stage 2B	Sediment	Pace	Yes	Yes, OK.
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	e-Lab Inc.	NA	NA
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	e-Lab Inc.	NA	NA
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	e-Lab Inc.	NA	NA

Appendix D-1
Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW07	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Sediment Core Database	db_SedCore	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Yes	NA	NA	Yes	NA	B. Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Yes	NA	NA	Yes	NA	B. Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Yes	NA	NA	Yes	NA	B. Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Yes	NA	NA	Yes	NA	B. Lawrence
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Yes, selected targets qualified due to MB, internal standard exceedance, and matrix interference.	Yes, selected targets qualified due to MS/MSD recoveries.	Yes	Yes	Yes	A. Spielman
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Yes, selected targets qualified due to MB, internal standard exceedance, and matrix interference.	Yes	Yes	Yes	Yes	A. Spielman
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki

Appendix D-1
Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F, which is not included in this document.		No QA info included in report.	SW8290	Dioxins/furans
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F, which is not included in this document.		No QA info included in report.	Plumb 1981	Grain size
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Cat 2	The laboratory report is not included. The data report states that this is in Appendix F, which is not included in this document.		No QA info included in report.	E415.1	TOC
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	Cat 2	Raw data file in Access.		No QA info included in report.	NA	Dioxins/furans
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	Cat 2	Raw data file in Access.		No QA info included in report.	NA	Grain size

Notes:

COC = chain-of-custody (between field and laboratory)

doc_id = document identification as assigned in the d_document.xls file

DQA = data quality assessment

HT = holding time

LCS = laboratory control sample

MS/MSD = matrix spike/matrix spike duplicate

NA = information not available

PCB = polychlorinated biphenyl

SVOC = semi-volatile organic compound

TEQ = Toxic Equivalents Quotient

TOC = total organic carbon

VOC = volatile organic compound

a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Data Study Reference	Project Description	doc_id	Independent Data Validation Performed?	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	Columbia Analytical Services	NA	NA
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	Weston Laboratory	NA	NA
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	Yes, Environmental Chemistry Services	NA	Sediment	Weston Laboratory	NA	NA
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	NA	NA	Sediment	NA	NA	NA
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	NA	NA	Sediment	NA	NA	NA

Notes:

COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
TEQ = Toxic Equivalents Quotient
TOC = total organic carbon
VOC = volatile organic compound
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-1
Historical Sediment Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Draft Field Activities Report for Sediment Sampling, San Jacinto River Bridge Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki
Weston 2006	Soil Boring Analytical Data for samples taken during TXDOTs San Jacinto River Bridge (I-10) Dolphin Project	TXDOT2006	NA	NA	NA	NA	NA	S. Wodzicki

Notes:

COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
TEQ = Toxic Equivalents Quotient
TOC = total organic carbon
VOC = volatile organic compound
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-2
Historical Water Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group	Independent Data Validation Performed?
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	TAMU-TERL	Metals, acid volatile sulfides, and tributyltin	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	350.2	Ammonia and nitrogen	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	8290	Dioxins/furans	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	160.1	Total dissolved solids	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	160.2	Total suspended solids	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	160.4	Volatile suspended solids	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	8030	Volatile organic - acrylonitrile	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	8240	Volatile organics	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	8270	SVOC	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	625	SVOC - benzidine,N-Nitrosodimethylamine	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix A, which is not included in this document.		No QA info included in report.	8080	Pesticides and PCBs	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	1613B	Dioxins/furans	Data review conducted, although not verified as independent.
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	160.1	Total dissolved solids	Data review conducted, although not verified as independent.

Appendix D-2
Historical Water Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	Texas A&M University, Trace Element Research Laboratory	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	Triangle Laboratories	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	AnalytiKEM Laboratories or PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Surface water	PDP Analytical Services	NA	NA	NA	NA	NA	Yes	NA	B. Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Surface water	PSC/Maxxam Analytical	NA	NA	Yes	NA	NA	Yes	NA	B.Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Surface water	North Water District Laboratory Services (NWDLS)	NA	No	Yes	NA	NA	Yes	NA	B.Lawrence

Appendix D-2
Historical Water Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group	Independent Data Validation Performed?
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	160.2	Total suspended solids	Data review conducted, although not verified as independent.
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	415.2	Total organic carbon	Data review conducted, although not verified as independent.
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	415.2	Dissolved organic carbon	Data review conducted, although not verified as independent.
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins, PCBs, and pesticides	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel DioxinW07 Database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins	NA
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel RunoffW07 Database	db_RunoffW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins	NA
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Cat 1				EPA 8290	Dioxin	Yes; URS

Notes:

COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-2
Historical Water Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Surface water	North Water District Laboratory Services (NWDLS)	NA	No	Yes	NA	NA	Yes	NA	B.Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Surface water	North Water District Laboratory Services (NWDLS)	NA	NA	Yes	NA	NA	Yes	NA	B.Lawrence
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Surface water	North Water District Laboratory Services (NWDLS)	NA	NA	Yes	NA	NA	Yes	NA	B.Lawrence
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel Dioxin W04 Database	db_DioxinW04	NA	Stormwater, surface water	NA	NA	NA	NA	NA	NA	NA	NA	C Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel DioxinW07 Database	db_DioxinW07	NA	Surface water	NA	NA	NA	NA	NA	NA	NA	NA	C Hutchings
University of Houston and Parsons 2006	University of Houston's TMDL in Houston Ship Channel RunoffW07 Database	db_RunoffW07	NA	Stormwater	NA	NA	NA	NA	NA	NA	NA	NA	C Hutchings
URS 2010	TCEQ San Jacinto Pits 0909 DUS Draft	URS_2010	Stage 2B	Surface water	Pace	Yes	Yes-OK	Yes; selected targets qualified due to MB, internal standard	Yes	Yes	Yes; selected results qualified due	Yes	A. Spielman

Notes:

COC = chain-of-custody (between field and laboratory)

doc_id = document identification as assigned in the d_document.xls file

DQA = data quality assessment

HT = holding time

LCS = laboratory control sample

MS/MSD = matrix spike/matrix spike duplicate

NA = information not available

PCB = polychlorinated biphenyl

SVOC = semi-volatile organic compound

a Identifies the level of the data quality information available per Table 3-1 of this \

Appendix D-3
Historical Air Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter group	Independent Data Validation Performed?	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel - Quarterly Report No. 3, July 2006	UHouston2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	USEPA Method TO-9A, USEPA method 1613B	Dioxins/furans	Data review conducted, although not verified as independent.	NA	Air	Alta Analytical Laboratory, PSC Analytical	NA	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel - Quarterly Report No. 3, July 2006	UHouston2006a	Cat 2	QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	NIOSH 5040	Elemental and organic carbon	Data review conducted, although not verified as independent.	NA	Air	NA	NA	NA

Notes:
COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-3
Historical Air Chemical Data Quality Review

Data Study Reference	Project Description	doc_id	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer name
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel - Quarterly Report No. 3, July 2006	UHouston2006a	NA, data quality for field blanks were discussed, but there is no discussion of laboratory method blank results.	NA	Yes	Yes, for field co-located replicates only. Laboratory precision was not assessed.	NA	C. Torell
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel - Quarterly Report No. 3, July 2006	UHouston2006a	NA	NA	NA	NA	NA	C. Torell

Notes:
COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-4

Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group	Independent Data Validation Performed?
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	204.2	Antimony	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	206.2	Arsenic	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	210.2	Beryllium	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	213.2	Cadmium	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	218.1	Chromium (III)	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	220.2	Copper	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	236.2	Iron	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	239.2	Lead	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	245.1	Mercury	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	249.2	Nickel	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	270.2	Selenium	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	272.2	Silver	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	279.2	Thallium	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	289.2	Zinc	NA
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	Cat 2	QA data may be included in Appendix C, which is not included in this document.		No QA info included in report.	8290	Dioxins and Furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Summary of multiple .xls	Cat 2	Data from 19 Excel files on 23 fish species fillet (skin on and skin off), 2 shrimp species, eastern oyster, and blue crab for metals, butyltins, VOCs, SVOCs, 209 PCB congeners, PCB Aroclors, pesticides, herbicides, PAHs, phenols, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, butyltins, VOCs, SVOCs, 209 PCB congeners, PCB Aroclors, pesticides, herbicides, PAHs, Phenols, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 1993.xls	Cat 2	Data from 7 fish species fillet (skin on and skin off) and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 2000 database.xls	Cat 2	Data from 5 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans	NA

Appendix D-4
Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
ENSR and EHA 1995	Houston Ship Channel Toxicity Report	ENSR_1995	NA	Blue catfish, hardhead catfish, and blue crab	Triangle Laboratories	NA	NA	NA	NA	NA	NA	NA	B. Lawrence
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Summary of multiple .xls	NA	FilletSkOff, FilletSkOn, and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 1993.xls	NA	FilletSkOff, FilletSkOn, and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 2000 database.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I Stupakoff

Appendix D-4
Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group	Independent Data Validation Performed?
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 2007 database.xls	Cat 2	Data from 5 fish species fillet for metals, VOCs, SVOCs, PCB congeners, pesticides, herbicides, PAHs, phenols, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB congeners, pesticides, herbicides, PAHs, Phenols, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Lake 1999 data sheets.xls	Cat 2	Data from 7 fish species fillet and blue crab for metals, tributylin tin, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, tributylin tin, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Dickinson Bayou 1982.xls	Cat 2	Data from one shrimp species for metals. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: East Gal Bay database.xls	Cat 2	Data from 6 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs. Raw data available with no analytical methods described.		No QA info included in report.	NA	metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Gal Bay oyster 2000 database.xls	Cat 2	Data from eastern oyster for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Lake 1999 data sheets.xls	Cat 2	Data from 3 fish species fillet, eastern oyster, and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Green Lake (West Galveston Bay).xls	Cat 2	Data from 2 fish species fillet and blue crab for metals, PCB Aroclors, and pesticides. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, PCB Aroclors, and pesticides	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel 1972-1996.xls	Cat 2	Data from 2 fish species fillet and one crab species for metals and dioxins/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel 2004.xls	Cat 2	Data from 10 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel database.xls	Cat 2	Data from 7 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Lower Galveston Bay.xls	Cat 2	Data from 5 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, phenols, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, phenols, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Tabbs Bay 1983-1996.xls	Cat 2	Data from 3 fish species fillet and eastern oyster for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, phenols, and dioxin/furans	NA

Appendix D-4
Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Creek 2007 database.xls	NA	Fillet	NA	NA	NA	NA	NA	NA	NA	NA	I Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Lake 1999 data sheets.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Dickinson Bayou 1982.xls	NA	Edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: East Gal Bay database.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Gal Bay oyster 2000 database.xls	NA	Edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Clear Lake 1999 data sheets.xls	NA	Edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Green Lake (West Galveston Bay).xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel 1972-1996.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel 2004.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Houston Ship Channel database.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Lower Galveston Bay.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Tabbs Bay 1983-1996.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff

Appendix D-4
Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	DQA Category	Comments	Recommended Category Revision (Y/N)	Reason for Category 2 Designation	Analytical Method(s)	Parameter Group	Independent Data Validation Performed?
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Trinity Bay 1970-1990.xls	Cat 2	Data from 4 fish species fillet, 2 shrimp species, eastern oyster, and blue crab for metals, total PCB Aroclors, pesticides, herbicides, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report	NA	Metals, total PCB Aroclors, pesticides, herbicides, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Upper Galveston Bay datasheets.xls	Cat 2	Data from 7 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, and PAHs	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: UpperGalvestonBay-TrinityBay.xls	Cat 2	Data from 5 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB congeners, pesticides, herbicides, PAHs, phenols, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	metals, VOCs, SVOCs, PCB congeners, pesticides, herbicides, PAHs, phenols, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: West Gal Bay 1999 database.xls	Cat 2	Data from 6 fish species fillet and blue crab for metals, VOCs, SVOCs, PCB Aroclors, pesticides, herbicides, PAHs, and dioxin/furans. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, VOCs, SVOCs, PCB congeners, pesticides, herbicides, PAHs, phenols, and dioxin/furans	NA
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: West Galveston Bay 1969-1992.xls	Cat 2	Data from 4 fish species fillet and eastern oyster for metals, total PCB Aroclors, and pesticides. Raw data available with no analytical methods described.		No QA info included in report.	NA	Metals, total PCB Aroclors, and pesticides	NA
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	Cat 2	Additional QA data may be included in Appendix A, which is not included in this document.		Insufficient QA info provided.	1613B	Dioxins/furans	Data review conducted, although not verified as independent.
University of Houston and Parsons 2006	University of Houston TMDL in Houston Ship Channel Dioxin W04 database	db_DioxinW04	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins	NA
University of Houston and Parsons 2006	University of Houston TMDL in Houston Ship Channel Dioxin W07 database	db_DioxinW07	Cat 2	Database, no QA data.		No QA info included in report.	NA	Dioxins	NA

Notes:
COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
VOC = volatile organic compound
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

Appendix D-4
Historical Tissue Residue Data Quality Review

Data Study Reference	Project Description	doc_id	Data Usability Assessment Check Category[a]	Matrix	Laboratory	COC	HT	Method Blank(s)	MS/MSD	LCS	Replicates	Surrogate(s)	Reviewer Name
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Trinity Bay 1970-1990.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: Upper Galveston Bay datasheets.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: UpperGalvestonBay-TrinityBay.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: West Gal Bay 1999 database.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
TDSHS 2007	Texas Fish Tissue Data from the Texas Department of State Health Services	TDSHS_FshTss: West Galveston Bay 1969-1992.xls	NA	Fillet and edible	NA	NA	NA	NA	NA	NA	NA	NA	I. Stupakoff
University of Houston and Parsons 2006	Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Quarterly Report No. 3	UHoust2006a	NA	Gafftopsail catfish, blue catfish, channel catfish, hardhead catfish, blue crab, and prey species	PSC/Maxxam Analytical	NA	NA	Yes	NA	NA	Yes	NA	B. Lawrence
University of Houston and Parsons 2006	University of Houston TMDL in Houston Ship Channel Dioxin W04 database	db_DioxinW04	NA	Whole fish	NA	NA	NA	NA	NA	NA	NA	NA	C. Hutchings
University of Houston and Parsons 2006	University of Houston TMDL in Houston Ship Channel Dioxin W07 database	db_DioxinW07	NA	Whole fish	NA	NA	NA	NA	NA	NA	NA	NA	C. Hutchings

Notes:
COC = chain-of-custody (between field and laboratory)
doc_id = document identification as assigned in the d_document.xls file
DQA = data quality assessment
HT = holding time
LCS = laboratory control sample
MS/MSD = matrix spike/matrix spike duplicate
NA = information not available
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic compound
VOC = volatile organic compound
a Identifies the level of the data quality information available per Table 3-1 of this Work Plan.

APPENDIX E

DRAFT GEOCHEMICAL CHARACTERISTICS OF PRIMARY COPCS

DRAFT GEOCHEMICAL CHARACTERISTICS OF PRIMARY COPCS SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

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July 2010

1 INTRODUCTION

The general conceptual site model for the San Jacinto River Waste Pits site in Harris County, Texas (the Site) focuses on the characteristics of the primary chemicals of potential concern (COPCs) and indicator chemical group at the Site, dioxins and furans. Geochemical characteristics for the other primary COPCs identified for the Site (a number of metals and bis(2-ethylhexyl) phthalate [BEHP]) are presented below.

1.1 Aluminum

Aluminum is the most abundant metal in the Earth's crust, and the industrial production of aluminum metal is on the order of tens of millions of tons per year (Greenwood and Earnshaw 2005). Common igneous minerals, such as feldspars and micas, contain aluminum; these minerals, in turn, weather to form common clays such as kaolinite, montmorillonite, and vermiculite. Such natural weathering processes result in the release of aluminum in the environment. Human-related activities such as mining and smelting also result in the release of aluminum.

Aluminum occurs as a single oxidation state (3+) and does not undergo oxidation-reduction reactions in the environment. The geochemical behavior of aluminum in surface waters and soils is complex and variable; in the environment, the fate and transport of aluminum is strongly governed by pH, salinity, and complex forming species. The formation of complexes with anionic species such as hydroxide (OH^-), chloride (Cl^-), and sulfate (SO_4^{2-}) and similar exchange reactions with anionic moieties on organic matter and negatively charged mineral surfaces are the predominant complexation reactions. The primary solubility control on aluminum is gibbsite, $Al(OH)_3$. At circumneutral pH, the aluminum-hydroxyl compounds (e.g., $AlOH^{2+}$, $Al(OH)_2^+$) related to gibbsite are the dominant species. At lower pH values, sulfate (SO_4^{2-}) is a primary complexant, and the related aluminum-sulfate minerals provide the solubility control. The trivalent aluminum cation (Al^{3+}) is described as a type "A," or "hard," metal cation (Stumm and Morgan 1996). The strongest ligand complexes are formed with fluoride (F^-), and with oxygen containing complexants. Chloride complexes occur when low pH minimizes the concentration of hydroxide.

Aluminum is not generally observed to bioaccumulate in fish and shellfish (ATSDR, 2008a), but moderate bioaccumulation has been observed at lower trophic levels. Certain plants have been observed to significantly bioaccumulate aluminum. Human exposure to aluminum is primarily through the consumption of food items, and to a much lesser degree exposure through drinking water and inhalation. The U.S. Food and Drug Administration has determined that aluminum-containing food additives are generally safe, and the U.S. Environmental Protection Agency (EPA) has set a secondary maximum contaminant level for drinking water at 0.05 to 0.2 mg/L based on taste, smell, or color.

1.2 Arsenic

Arsenic is a naturally occurring metal that occurs widely in natural minerals, including realgar ($As_4S_{4(s)}$), orpiment ($As_2S_{3(s)}$), and arsenolite (As_2O_3) (ATSDR 2007a). Arsenic occurs naturally in soil, water, and air as a result of mineral weathering, leaching, volcanic eruptions, and windblown dirt. Typical crustal abundance of arsenic is low, 1 µg/g (Faure 1991); localized high concentrations are associated with mineralized areas or anthropogenic sources. Anthropogenic activities, including smelting activities, pesticide use, combustion of wood and coal, waste incineration, and the production and use of treated wood products that utilize soluble chromium copper arsenate can also release arsenic into the air, soil, water, and sediments.

Arsenic is a redox-sensitive species, existing at the 3+ and 5+ oxidation states in aqueous environmental conditions. Under oxidizing conditions, the As(V) species (H_3AsO_4, $H_2AsO_4^-$, $HAsO_4^{2-}$, AsO_4^{3-}) predominate, while under reducing conditions, the As(III) species (H_3AsO_3, $H_2AsO_3^-$, $HAsO_3^{2-}$, AsO_3^{3-}) predominate (EPRI 1984). Though arsenic is redox active, both the oxidation and reduction reactions can be kinetically slow; as such, it is not uncommon to observe a mixture of oxidized and reduced arsenic species in natural waters. Arsenic is generally highly soluble, with few mineral phases exerting controls on aqueous arsenic concentrations under typical environmental conditions. Arsenic sulfide minerals, such as orpiment ($As_2S_{3(s)}$) and realgar (As_4S_4(s)) can be important under reducing and acidic conditions. Although arsenic minerals are generally highly soluble, adsorption reactions to sediment/aquifer mineral grain surfaces frequently limit dissolved arsenic concentrations (Kabata-Pendias and Pendias 1992). Arsenic is particularly strongly adsorbed to iron oxide minerals, with the As(V) species having a greater affinity for the oxide surface than the As(III) species. Because arsenic is frequently present as an anion under typical environmental conditions, its sorption to oxide surfaces is favored at pH < 9 (Stumm 1992). Under reducing conditions reductive dissolution will re-release sorbed arsenic. Phosphate is also known to compete with arsenic anions for sorption sites, and high concentrations may result in the release of sorbed arsenic anions.

In aquatic environments, bioaccumulation of arsenic occurs primarily in algae and invertebrates (ATSDR 2007a). Fish and shellfish can also accumulate arsenic, mainly in the exoskeleton of invertebrates and in the livers of fish. While biomagnification in aquatic food chains is not generally considered significant, predatory fish may biomagnify arsenic through the consumption of prey species (especially bottom dwellers) (ATSDR 2007a).

1.3 Barium

Barium is an alkaline earth metal with a typical crustal abundance of 250 μg/g (Faure 1991). Barium is present naturally in ore deposits and may be released through anthropogenic activities. The primary ore of barium is barite ($BaSO_4$) and is found primarily in formations of calcite, dolomite, and related sedimentary deposits (ATSDR 2007b). The vast majority (92 percent) of barite is used as high density mud for drilling operations; the remainder is used in the production of alloys and barium chemicals (Greenwood and Earnshaw 2005).

Barium exists only in the 2+ valence state in aqueous environments (EPRI 1984). Barite ($BaSO_{4(s)}$) and witherite ($BaCO_{3(s)}$) are the predominant naturally occurring mineral forms of barium (Deer et al. 1966), but barium can also occur as a minor substituent in carbonate minerals such as calcite (Lindsay 2001). This substitution is limited by the larger radius of the barium ion. Barium typically exhibits limited mobility in the environment because it has a strong tendency to precipitate as sulfate (barite) and carbonate (witherite) minerals and its sorbs strongly to clay minerals. Barite frequently controls the solubility of barium in natural waters (Hem 1985). Solubility control by barite is often demonstrated in estuarine environments—barium dissolved in freshwater will become supersaturated when mixed with seawater having much higher typical sulfate concentrations (ATSDR 2007b). The solubility limits on barium in solutions, primarily by barite, and secondarily by witherite, result in characteristically fast precipitation kinetics (EPRI 1984). Barium also is strongly adsorbed by clays and oxide minerals—particularly manganese oxides (Charette and Sholkovitz 2006). Researchers have shown that barium has a significantly greater affinity to manganese oxides than to iron oxides (Charette and Sholkovitz 2006), although both can be important determinants in the fate and transport of barium in the environment.

Uptake of barium by marine biota has been identified as an important mechanism for removal of barium from the dissolved state, and bioconcentration factors from 400 to 4,000 have been observed in the marine environment (ATSDR 2007b).

1.4 Cadmium

Cadmium is a transition metal with a crustal abundance of approximately 0.098 µg/g (Faure 1991). A chalcophile element, cadmium is present in sulfidic ore bodies and is commonly associated with zinc and copper sulfides. Natural sources of cadmium include volcanic activity, weathering, and forest fires. Anthropogenic sources include mining and smelting, use in batteries, fuel combustion, disposal of metal-bearing wastes, and fertilizer use (ATSDR 2008b). Of these, the 83 percent of the industrial use is in batteries.

In the environment, cadmium occurs in two redox states: the elemental, Cd^0, and the Cd^{2+} valence state. The divalent form dominates between pH 4.0 and 7.0 (USEPA 2000). In aquatic environments, cadmium is relatively insoluble in water and is not affected by photolysis, volatilization, or biological methylation (USEPA 1999). Although chloride and sulfate cadmium salts are freely soluble, precipitation and sorption to mineral surfaces and organic materials are dominant processes controlling fate and transport of cadmium compounds. The sorption reactions of cadmium to the dominant phases in sediments (e.g., clays, humics, silica) are rapid and the concentration factors (K_d) are large (5,000 to 500,000) (Eisler 1985). These characteristics favor the deposition and retention of cadmium in sediment. The speciation of Cd^{2+} in water is minimally affected by redox conditions; under reducing conditions, the presence of sulfide (S^{2-}) will lead to the formation of insoluble CdS. The divalent cadmium cation (Cd^{2+}) is described as a type "B," or "soft," metal cation (Stumm and Morgan 1996). The strongest ligand complexes are formed with sulfide (S^{2-}), and in decreasing order of binding strength chloride and oxygen. In most waters, the primary solubility limiting phase is $CdCO_3$ (EPRI 1984); however, concentrations observed are generally below the $CdCO_3$ solubility limit (Hem 1985). Rather, the primary controls on aqueous speciation and solubility are pH and humic substances (ATSDR 2008b). Sorption to solid phase mineral surfaces and organic material may control the concentration of cadmium in natural waters. In comparison to most heavy metals, cadmium is more mobile, and, in unpolluted waters, is generally present in the dissolved phase as the hydrated ion $Cd(H_2O)_6^{2+}$ (ATSDR 2008b). In a typical aerobic freshwater, at pH<8, the primary dissolved cadmium species will be Cd^{2+}, at pH 8–10 $CdCO_3$, and at higher pH values $Cd(OH)_2$ (Callendar 2003). In more complex freshwaters, cadmium-organic matter complexes can be important species. With increasing salinity, the speciation of dissolved cadmium shifts to dominance by the series of cadmium-chloride complexes ($CdCl^-$, $CdCl_2$, $CdCl_3^-$).

The bioavailability of cadmium is dependent on several factors, including sorption and desorption rates, pH, Eh, chemical speciation, and many other modifiers. The concentration of acid-volatile sulfide is known to be an important factor controlling the toxicity and bioaccumulation of cadmium in sediments (USEPA 2000). Cadmium has been observed to bioaccumulate at all levels of the food chain. Cadmium toxicity is associated with the free cadmium ion (Cd^{2+}) (ATSDR 2008b). The presence of complexing species, such as chloride or humic substances, may limit the toxicity of cadmium. Cadmium is known to serve no essential biological function (Eisler 1985). EPA has set a drinking water standard for cadmium at 5 μg/L.

1.5 Chromium

Chromium is a relatively abundant trace metal in the Earth's crust, occurring at a concentration of approximately 185 μg/g (Faure 1991). The release of chromium to the environment is both the result of natural processes, such as weathering, and anthropogenic emissions, such as mining and metal processing, coal combustion, municipal incineration, and cement production. However, the magnitude of release from natural processes, estimated at 32,000 tons/ year, is dwarfed by the annual world production of 7 million metric tons (Eisler 1986). Anthropogenic emissions of chromium constitute from 60 to 70% of the total atmospheric load (ATSDR 2008c) and most of the Cr^{6+} in the environment is the result of anthropogenic emissions (Eisler 1986)

Chromium is a redox active element, at environmentally relevant conditions, it occurs in two oxidation states: Cr^{3+} and Cr^{6+}. The species that are considered stable in aqueous systems are

Cr^{3+}, $CrOH^{2+}$ (dominant at pH 4–6), $Cr(OH)_2^{+}$, $Cr(OH)_3$ (dominant at pH 6 to 11.5), $Cr(OH)_4^{-}$ (dominant at pH >11.5), and under oxidizing conditions, $Cr_2O_7^{2-}$ and CrO_4^{2-} (Callendar 2003; Hem 1985). The trivalent form of chromium is stable over a wide range of pH and Eh; hexavalent chromium is stable under strongly oxidizing conditions.

Biologically, Cr^{3+} is the dominant form of chromium. In the aquatic phase dissolved chromium accounts for a small fraction of total chromium, and is typically present as Cr^{6+} or as Cr^{3+} complexes. The two redox species of chromium show strongly divergent chemical characteristics, Cr^{3+} has very low solubility and low reactivity—resulting in low mobility; in contrast, Cr^{6+} is soluble, mobile, and more toxic. In the dissolved phase, the high solubility of the Cr^{6+} species results in its dominance, where it is present as a series of anionic species (CrO_4^{2-}, $HCrO_4^{-}$, and $Cr_2O_7^{2-}$) (Eisler 1986). In solution, most Cr^{6+} will be reduced to Cr^{3+} by organic matter or other reducing substances.

Trivalent chromium forms strong complexes with anionic moieties, such a mineral surfaces or sediment organic matter, and is effectively removed from the dissolved phase. This is consistent with the observation of Cr^{3+} concentrations being highest in finer grained sediments and those rich in organic matter and iron oxides (Eisler 1986). Salinity affects the sorption of Cr^{3+} to sediments, with maximum sorption occurring in a salinity range of 0.1 to 1.0 ‰ (Eisler 1986). Non-dissolved chromium occurs primarily as suspended solids, where the chromium is sorbed onto clays, iron oxides, or organic matter (ATSDR 2008c). Most of the chromium released into water will be sorbed to sediment. In addition to adsorption reactions, the rapid hydrolysis and precipitation of $Cr(OH)_3$ and coprecipitation with $Fe(OH)_3$ will strongly limit the aqueous concentrations of Cr^{3+}. In both freshwater and marine environments, hydrolysis and precipitation dominate the fate and transport of chromium (Eisler 1986). Kinetics of the reduction of Cr^{6+} to Cr^{3+} are faster under anaerobic and acidic conditions, and half-lives are highly variable ranging from 4 to 140 days (ATSDR 2008c).

Chromium is not expected to bioaccumulate in either aquatic or terrestrial food chains (ATSDR 2008c). However, Cr^{3+} is also an important component of some metabolic biomolecules and is an essential trace metal.

1.6 Cobalt

Cobalt is a transition metal that has a low abundance (29 μg/g) in the Earth's crust, relative to other metals in the first transition series (Faure 1991). Production of cobalt in 1995 was approximately 20,000 tonnes; the majority was consumed in the paint and ceramic industry, with additional use as an alloying material (Greenwood and Earnshaw 2005). Cobalt is a metal of biochemical importance, as the central atom in the organometallic compound cyanocobalamin, or Vitamin B_{12}. In addition, radioactive isotopes of cobalt are of commercial importance. Natural sources of cobalt to the environment include the weathering of host rock, forest fires, and volcanism; anthropogenic sources include mining and mineral processing, fossil fuel and waste combustion, and the manufacture and use of cobalt containing chemicals. The natural sources of cobalt are estimated to slightly exceed the anthropogenic sources (ATSDR 2004b).

Cobalt occurs in both the Co^{2+} and Co^{3+} oxidation states at environmental conditions. The primary controls on cobalt concentrations in water are thought to be coprecipitation and adsorption by manganese and iron hydroxides (Hem 1985). Cobalt carbonate ($CoCO_3$) may be a primary control on solubility; however, this solubility limit may rarely be reached due to complexation and sorption reactions occurring in solution (Hem 1985). Humic substances are strong complexants of cobalt in natural waters. Under reducing conditions that promote the formation of sulfide (S^{2-}), insoluble CoS may form. In freshwater, speciation modeling of cobalt has found that the dominant species are free cobalt (Co^{2+}), $CoCO_3$, $CoHCO_3^+$, and to a lesser degree $CoCl^+$, $CoSO_4$, and cobalt-humic acid species. However, due to uncertainty in complexation stability constants, the results of complexation modeling have been variable (ATSDR 2004b). With increasing alkalinity, the cobalt-carbonate species increase at the expense of free cobalt. In seawater, dominant cobalt species are similar species to those in freshwater. However, increasing salinity decreases complexation with humic substances, and $CoSO_4$ becomes more significant. Decreasing pH is associated with decreased cobalt complexation on sediments and organic matter; due to competition for anionic binding sites with increasing proton concentrations.

Cobalt is generally not thought to bioaccumulate in the food chain, and uptake by plants is generally thought to be minimal (ATSDR 2004b). The low level of bioaccumulation is related to the strong preference for cobalt to partition to soils and sediments. Cobalt has been identified as a possible human carcinogen (ATSDR 2004b) and has been implicated in a range of adverse health effects.

1.7 Copper

Copper is a relatively abundant, but trace, metal (68 parts per million [ppm]) in the Earth's crust, and natural releases to environmental media can be significant. Mining operations, agriculture, wastewater sludge, municipal and industrial solid waste, and other industrial processes can also result in environmental releases of copper (ATSDR 2004a).

Copper exists in four oxidation states: Cu^0, Cu^+, Cu^{2+}, and Cu^{3+} (Eisler 1998). The cupric ion (Cu^{2+}) is the one generally encountered in water and it is the most readily available and toxic inorganic species of copper. However, the free ion concentration is sensitive to complexation with numerous compounds normally found in natural waters, or partitioning to dissolved and particulate organic carbon. Both processes result in reduced bioavailability to aquatic organisms (Eisler 1998; USEPA 2000). The amounts of the various copper compounds and complexes present in solution in freshwater depend on water pH, temperature, hardness, and alkalinity; concentrations of bicarbonate, sulfide, and organic ligands; size and density of suspended materials; and rates of coagulation and sedimentation of particulates. Up to 29 different species of copper can be present in aqueous solution in the pH range of 6 to 9. The majority of copper in freshwater from pH 6.0 to 9.3 is in the form of carbonate species ($CuHCO_3^+$, $CuCO_3$, $Cu(CO_3)_2^{2-}$), which have low toxicity (Eisler 1998). Cupric ions account for less than 1 percent of the total dissolved copper in freshwater. Copper carbonate, cupric hydroxide, cupric oxide, and cupric sulfide will precipitate from solution or form colloidal suspensions when excess cupric ions are present (Eisler 1998). The divalent copper cation (Cu^{2+}) is described as a type "B," or "soft," metal cation (Stumm and Morgan 1996). The strongest ligand complexes are formed with sulfide (S^{2-}), and in decreasing order of binding strength, chloride and oxygen. With increasing salinity, chloride will transition to become the dominant complex-forming ligand. In sulfate-reducing environments, copper will tend to form insoluble copper sulfide precipitates.

The majority of copper released to surface waters settles out or adsorbs to sediments (USEPA 1999; Eisler 1998). Bioavailability of copper in sediments is controlled by the degree of complexation with acid-volatile sulfide and adsorption to organic matter (USEPA 2000). Copper is taken up by aquatic organisms primarily through dietary exposure and is an essential micronutrient for animals as a component of a number of essential enzymes (USEPA 2000). Most organisms retain only a small proportion of the copper ingested with their diet. In freshwater and marine systems, copper is among the most toxic heavy metals (Eisler 1998). Copper bioconcentrates in aquatic organisms, but does not bioaccumulate in mammals or biomagnify in aquatic food chains (USEPA 1999).

1.8 Lead

Lead is the most abundant heavy metal in the Earth's crust occurring at concentrations of approximately 8 μg/g (Faure 1991). Lead is released to the environment by a variety of human activities, including burning fossil fuels, mining, and manufacturing. Lead is commonly used in a variety of products; however, in response to health concerns, lead use in gasoline, paints, and pipe solder has been dramatically reduced in recent years (ATSDR 2007c). In the U.S., the dominant use for lead (84 percent) is in automotive batteries. Releases of lead to the environment are primarily from anthropogenic sources; these sources have been dominated by the use of organolead compounds in automotive gasoline, and also by emissions from mining and smelting operations.

Lead occurs in three valence states: elemental (Pb^0), divalent (Pb^{2+}), and tetravalent (Pb^{4+}). In nature, lead occurs mainly as Pb^{2+}; Pb^{4+} is a strong oxidizing agent, and few simple compounds of Pb^{4+} other than PbO_2 are stable. Some lead salts are comparatively soluble in water (lead acetate, 443 g/L; lead nitrate, 565 g/L; lead chloride, 9.9 g/L), whereas others are only sparingly soluble (lead sulfate, 42.5 mg/L; lead oxide, 17 mg/L; lead sulfide, 0.86 mg/L). The transport of lead in the environment is primarily limited by the low solubility of lead hydroxy-carbonates (Hem 1985). Precipitation of lead sulfate in soft waters also provides a solubility control (ATSDR 2007c). The dominant aqueous species of lead are determined by pH: below pH 6, $PbSO_4$ is dominant, or Pb^{2+} in low-sulfate environments; in circumneutral pH, $Pb(CO_3)_2^{2-}$ is dominant; and above pH 8, $Pb(OH)_2$ is dominant (Callendar 2003). Additional solubility control is provided by the sorption of lead to mineral and organic surfaces in sediments. Because of the numerous solubility controls, the fate and transport of lead in the environment are strongly tied to the transport of undissolved lead present within, or sorbed to, particulates. Only at low pH conditions is the transport of dissolved lead of environmental importance; increased proton competition at low pH decreases the amount of Pb^{2+} complexation with sorption surfaces. In seawater, the dominant lead species are $PbCO_3$ and $PbCl^-$. Of the organoleads, tetraethyllead and tetramethyllead are the most stable and the most important because of their widespread use as antiknock fuel additives. Both undergo photochemical degradation in the atmosphere to elemental lead and free organic radicals, although the fate of automotive organoleads has yet to be fully evaluated (Eisler 1988). In general, food chain biomagnification of lead is negligible (Eisler 1988).

In general, organolead compounds are more toxic than inorganic lead compounds. Food chain biomagnification of lead is negligible, and younger organisms are most susceptible (Eisler 1988). Lead plays no beneficial biological role, and all the effects observed from lead are adverse. Lead has been demonstrated to have a wide range of adverse affects on both humans and ecosystems.

1.9 Magnesium

Magnesium is among the most abundant elements—in crustal rocks it accounts for approximately 3 percent, and it occurs in seawater at an abundance of 0.1 percent. Magnesium naturally occurs as the minerals dolomite, magnesite, and carnellite. It is extensively used as a structural metal and in alloys and is produced on the scale of 400,000 tons per year (Greenwood and Earnshaw 2005).

Magnesium exists at a single oxidation state (2+) and does not undergo oxidation-reduction reactions in the environment. The divalent magnesium cation (Mg^{2+}) is described as a type "A," or "hard," metal cation (Stumm and Morgan 1996). The strongest ligand complexes are formed with fluoride (F^-) and with oxygen-containing complexants. Chloride complexes occur when low pH minimizes the concentration of hydroxide. Magnesium carbonates are significantly more soluble than calcium carbonates, and as such, the concentration of magnesium in seawater is roughly five times that of calcium. Magnesium is of concern in water most often as one of the two (along with calcium) components of hardness. Magnesium forms a number of silicate-containing minerals (serpentine, sepiolite, and some amorphous phases) that along with magnesite ($MgCO_3$) control the solubility of magnesium under environmental conditions (Faure 1991). Dolomite is found in extensive deposits, but is observed to form infrequently. In solution, hydroxide and carbonate are likely to dominant the speciation of magnesium.

Magnesium is an essential metal for human health and is the fourth most abundant mineral in the body.

1.10 Manganese

Manganese is transition metal that is the 12th most abundant element in the Earth's crust, accounting for approximately 0.1 percent of the Earth's crust. Manganese does not occur in nature in elemental form, but is found mainly as oxides, carbonates, and silicates. The most common manganese minerals are pyrolusite (MnO_2), rhodochrosite ($MnCO_3$), hausmannite (Mn_3O_4), and rhodonite ($MnSiO_3$). Manganese is released into the environment via natural processes, such as the erosion of rocks and soils, and anthropogenic activities, such as mining and mineral processing, industrial waste disposal, or by the leaching of manganese from anthropogenic materials discarded in landfills or soil, such as dry-cell batteries. Manganese exists in both inorganic and organic forms. The dominant use (>90 percent) of manganese is in steel production (Greenwood and Earnshaw 2005), with the remainder used in a variety of industrial processes. Organic forms of manganese are used as fungicides, fuel-oil additives, smoke inhibitors, an anti-knock additive in gasoline, and a medical imaging agent (ATSDR 2008d).

Manganese occurs in three primary valences (Mn^{2+}, Mn^{3+}, and Mn^{4+}), and forms a range of mixed-valence oxides (Hem 1985). Mn^{2+} predominates in most waters (pH 4–7); however, under alkaline conditions, it may become oxidized. In natural waters, the principal anion associated with Mn^{2+} in water is usually carbonate (CO_3^{2-}), and the concentration of manganese is limited by the relatively low solubility (65 mg/L) of rhodochrosite. Only under very high pH (10.5) do manganese-hydroxide species become important (Hem 1985). Under oxidizing conditions, the solubility of Mn^{2+} may be controlled by manganese oxide equilibria, with manganese being converted to Mn^{2+}or Mn^{4+} oxidation states. In extremely reduced water, the fate of manganese tends to be controlled by formation of a poorly soluble sulfide (ATSDR 2008d). Manganese is often identified as a redox active element in natural surface and ground waters; the formation of manganese oxyhydroxides (MnOOH) may act as a control for both manganese concentrations and for other metals that sorb or coprecipitate with the MnOOH. The rates of redox reactions for manganese are highly variable, and strongly related to both biological activity and the presence of solid surfaces as reaction sites (Hem 1985). Because of the importance of redox reactions to manganese solubility, the rates of redox reactions may control aqueous solubility. Manganese is often transported in rivers as suspended sediments. The tendency of soluble manganese compounds to adsorb to soils is dependent upon the cation exchange capacity and the organic composition of the soil. At low concentrations, manganese may be “fixed” by clays and will not be released into solution readily. At higher concentrations, manganese may be desorbed by ion exchange mechanisms with other ions in solution (ATSDR 2008d).

Bioconcentration of manganese occurs at lower trophic levels. EPA has set a drinking water standard of 0.3 mg/L for manganese.

1.11 Mercury

Mercury sources are both natural and anthropogenic; primary human activities resulting in releases to the environment are mining and smelting, industrial processes involving the use of mercury including chlor-alkali production facilities, combustion of fossil fuels (primarily coal), production of cement, and medical and municipal waste incinerators, and industrial/commercial boilers (ATSDR 1999).

Mercury may be present in the environment in a number of forms and can exist in three oxidation states: elemental mercury (Hg^0), mercurous ion (Hg_2^{2+}), and mercuric ion (Hg^{2+}). Mercury compounds in aqueous solution are chemically complex. Depending on pH, alkalinity, redox, and other variables, a wide variety of chemical species may be formed. Nonvolatile inorganic forms of mercury compounds sorb readily to sediments, particularly those containing high organic carbon and reduced sulfur levels (USEPA 2000). Mobilization of sorbed mercury can be caused by bioreduction to elemental mercury and bioconversion to more volatile and soluble forms, such as methylmercury. Methylmercury is the most hazardous mercury species due to its high stability, its lipid solubility, and its ionic properties that allow it to readily pass through cellular membranes (Eisler 1987). The divalent mercury cation (Hg^{2+}) is described as a type "B," or "soft," metal cation (Stumm and Morgan 1996). The strongest ligand complexes are formed with sulfide (S^{2-}), and in decreasing order of binding strength chloride and oxygen. In freshwater, mercury complexation will be dominated by hydroxide (OH^-) and organic matter; with increasing salinity, chloride will transition to become the dominant complex-forming ligand. In sulfate-reducing environments, mercury will tend to form insoluble mercury sulfide precipitates.

Mercury that is discharged into rivers, bays, or estuaries can be converted into methylmercury compounds by natural biological (bacterial microorganisms) or chemical processes (Eisler 1987). The mercury methylation process depends on mercury loadings, microbial activity, nutrient content, pH and redox condition, suspended sediment load, sedimentation rates, and other variables; anaerobic conditions favor methylmercury formation more than aerobic conditions (Eisler 1987). Bacterial microbes are also responsible for methylmercury decomposition (demethylation). They are widespread in the environment and have been isolated from water, sediments, soils, and from the gastrointestinal tract of mammals, including humans.

Mercury is accumulated by all trophic levels, with biomagnification occurring through the food web (USEPA 2000). The transfer efficiency of mercury through the food web is affected by the form of mercury. Although inorganic mercury is the dominant form in the environment and is easily accumulated, it is also depurated quickly. Methylmercury accumulates quickly and depurates very slowly, and therefore has a greater potential to biomagnify in higher trophic level species. Mercury methylation has been shown to be a microbially mediated process, in which sulfate-reducing bacteria have been implicated.

1.12 Nickel

Nickel ranks 24th in order of abundance in the Earth's crust, occurring with an abundance of approximately 105 μg/g (Faure 1991). Nickel ore deposits are of two general types: magmatic sulfide ores, which are mined underground, and lateritic hydrous nickel silicates or garnierites, which are surface mined (ATSDR 2005a). Nickel forms useful alloys with many metals; it is added to metals to increase their hardness, strength, and corrosion resistance. Sources of nickel to the environment include natural processes such as weathering, volcanoes, and forest fires. Anthropogenic sources of nickel include emissions from mining and mineral processing, combustion processes, and chemical manufacturing. It has been estimated that annual natural nickel inputs from weathering are approximately 540,000 tons per year and that industrial emissions of nickel to the environment total approximately 356,000 tons per year (Callendar 2003).

Nickel normally occurs in two oxidation states (0) and (2+); in natural waters, the divalent species is dominant. At circumneutral pH, the dominant dissolved species is the hydrated ion $(Ni(H_2O)_6)^{2+}$; to a lesser degree complexes will also form with common anionic species (e.g., OH^-, SO_4^{2-}, Cl^-). Under anaerobic conditions, solubility will be controlled by the precipitation of NiS, and under aerobic conditions, solubility will be controlled by $Ni(OH)_2$ and $NiFe_2O_4$ (Callendar 2003). Solubility controls are not often reached however, due to strong binding of nickel to iron and manganese oxyhydroxides and related mineral surfaces. Under alkaline conditions the nickel hydroxide will form ($NiOH^+$), and under acidic conditions, nickel sulfate ($NiSO_4$) and nickel phosphate ($NiHPO_4$) will form (Eisler 1998). The fate of nickel in aquatic systems depends on partitioning between soluble and particulate solid phases, which is influenced by pH, redox potential, the ionic strength of the water, the concentration of complexing ions, and the species and concentration of the metal. In typical river water, the transport of dissolved nickel accounts for only a small fraction (<1 percent) of nickel transport, whereas transport within or sorbed to solid phases accounts for approximately 85 percent of nickel transport (Callendar 2003).

It has been reported that nickel is not accumulated in significant amounts by aquatic organisms. There is no evidence that nickel biomagnifies in aquatic food webs, but there is evidence to indicate that nickel concentrations in organisms decrease with increasing trophic level (ATSDR 2005a). The availability and toxicity of nickel is strongly dependent on the chemical form.

1.13 Vanadium

Vanadium is the 22nd most abundant element in the Earth's crust with an average concentration of 100 mg/kg. Vanadium is primarily used in the production of rust-resistant, spring, and high-speed tool steels; vanadium pentoxide is used in ceramics (ATSDR 2009).

Natural sources of vanadium to water include wet and dry deposition, soil erosion, and leaching from rocks and soils. The largest amount of vanadium release occurs naturally through water erosion of land surfaces. Anthropogenic sources of vanadium in water may include mining and mineral processing, urban sewage sludge, and certain fertilizers. Vanadium is high in certain crude oils and may be recovered from oil processing and flue dusts (Greenwood and Earnshaw 2005). A related source is airborne particulate matter that is deposited in areas with high residual fuel oil combustion (ATSDR 2009). Anthropogenic releases to water and sediments are far smaller than natural sources.

Vanadium occurs in oxidation states ranging from 1– to 5+. Three of these valences, 3+, 4+, and 5+, are stable in aqueous solution, and V^{5+} complexes with oxygen and hydroxide are dominant (Hem 1985). The redox conditions of the environment affect vanadium. Under reducing conditions, the vanadyl ion (V^{4+}) dominates, and under oxidizing conditions, the vanadate ion (V^{5+}) dominates. It has been observed that the aqueous solubility of less oxidized forms of vanadium are relatively low, except at low pH, <4.0 (Hem 1985). Both oxidation states undergo hydrolysis in solution to form a range of products: for vanadyl (V^{4+}), VO^{2+} and $VO(OH)^{+}$, and for vanadate, (V^{5+}), $H_2VO_4^{-}$ and HVO_4^{2-}. In seawater, vanadium forms similar anionic oligomeric hydrolysis species to those in freshwater. These species include VO^{3+}, HVO_4^{2-}, and $H_2V_4O_{13}^{4-}$. The transport and partitioning of vanadium in water and soil is influenced by pH, redox potential, and the presence of particulates. Both vanadate and vanadyl species are known to bind strongly to mineral or organic matter surfaces by adsorption or complexation. The result of this strong binding is that only 13 percent of vanadium is transported in solution, while the remaining 87 percent is in suspension (ATSDR 2009). In seawater, the co-precipitation and co-sedimentation of vanadium with organic matter and hydrous ferric oxides particulates provides a continuous sink for vanadium.

Some bioaccumulation of vanadium is observed in plants, particularly in marine plants. However, little or no accumulation is observed in terrestrial animals, where levels are often below detection limits (ATSDR 2009). In humans, vanadium is observed to be rapidly excreted.

1.14 Zinc

Zinc is ubiquitous in the environment, constituting approximately 80 µg/g of the Earth's crust (Faure 1991). Elemental zinc in not found in nature—instead it primarily occurs as zinc oxide or sphalerite (ZnS). Zinc is released into the environment as the result of mining and smelting of zinc, lead, and cadmium ores, steel production, coal burning, and waste incineration. Releases of zinc to the environment can be the result of both natural processes, such as weathering of zinc containing rock, or anthropogenic activities. However, the latter dominate global emissions, accounting for approximately 96 percent of the estimated annual emission rate of 8.8 million tons (Eisler 1993). Within organisms, zinc is an essential trace element, and it occurs in a large number of metalloenzymes and metabolic compounds.

Zinc occurs in the environment in the (2+) valence state. In water, the free zinc ion is thought to coordinate with six water molecules to form the octahedral aquo ion, $(Zn(H_2O)_6)^{2+}$, in the absence of other complexing or adsorbing agents (Eisler 1993). Zinc is capable of forming complexes with a variety of ligands (ATSDR 2005b), primarily carbonate, chloride, sulfate, and humic substances. In typical river waters, 90 percent of the zinc is present as the aquo ion, and the remainder consists of $(ZnHCO_3^+)$, zinc carbonate $(ZnCO_3)$, and zinc sulfate $(ZnSO_4)$ (Eisler 1993). Only at pH >8 does $ZnCO_3$ predominate over Zn^{2+} (Callendar 2003). The solubility of hydroxy- and carbonate-zinc species generally provide solubility control. In seawater, dissolved zinc is present as $ZnOH^+$, $Zn^{2+,}$ $ZnCl^+$, and $ZnCO_3$; at pH 8 the dominant species is $ZnOH^+$(approximately 60 percent) and when pH declines to pH 7, Zn^{2+} becomes dominant (approximately 50 percent). Zinc in the water column can partition to dissolved and particulate organic carbon.

Because zinc ligands are soluble in neutral and acidic solutions, zinc is readily transported in most natural waters (Eisler 1993). Most of the zinc introduced into aquatic environments eventually is partitioned into the sediments (Eisler 1993). Zinc release from sediments is enhanced under conditions of high dissolved oxygen, low salinity, and low pH (Eisler 1993). Water hardness, pH, and metal speciation are important factors in controlling the activity of divalent zinc in the water column.

Bioavailability of zinc in sediments is controlled by acid-volatile sulfide concentration. Most studies reviewed contained data that suggest that zinc is not a highly mobile element in aquatic food webs, and there appears to be little evidence to support the general occurrence of biomagnifications of zinc with in marine or freshwater food webs (USEPA 2000).

1.15 Bis(2-ethylhexyl) Phthalate

BEHP is a phthalate compound. Phthalates are manufactured, colorless liquids with little or no odor. The primary sources of phthalate emissions are the industries that manufacture it or use it in production, such as the chemical industry, the plastics industry, machinery manufacturers, and manufacturers of plywood and millwork. Phthalates are commonly added to plastics and paint to make the finished product more flexible (ATSDR 2002). Releases to the environment can occur as direct spills from industrial facilities that manufacture or use these chemicals. More commonly, releases occur by leaching of low volumes of phthalates from the wide variety of products that contain them (ATSDR 2002). Despite its low vapor pressure (1.0×10^{-7} mm Hg at 25°C), BEHP is present in the atmosphere in both the vapor phase and in association with particulates and is subject to both wet (rain and snow) and dry (wind and settling) deposition on the Earth's surface (ATSDR 2002).

The behavior of BEHP in the environment is largely defined by its high hydrophobicity (log K_{oc} 4–6; log K_{ow} 4.89–7.5; ATSDR 2002; USEPA 2010). Due to this hydrophobicity, BEHP has a strong tendency to sorb to solids and organic matter in surface water and in sediment-porewater environments. As such, it is not expected to migrate significantly in groundwater. Due to the low vapor pressure of BEHP, volatilization is a minor loss mechanism for BEHP, particularly when sorbed to solids. BEHP is subject to fairly rapid degradation in the atmosphere, but much slower abiotic and microbially mediated degradation processes occur under aerobic conditions in sediment and surface water (ATSDR 2002). *In situ* half-lives for phthalate esters in sediment are estimated to be on the order of several months (Staples et al. 1997).

BEHP bioconcentrates in invertebrates, fish, and terrestrial organisms; however, BEHP is quickly metabolized in higher organisms, which prevents biomagnification. Human exposure to phthalates is through consumption of food and drinking water (ATSDR 2002). Studies of the environmental fate of BEHP can be confounded by several factors. BEHP is a common laboratory contaminant, and water and biological samples are particularly subject to BEHP contamination during sample collection, handling, and processing for analysis. The presence of humic and fulvic acids and other organic compounds found in natural waters can affect the solubility of BEHP, complicating fate and transport studies.

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APPENDIX F
SELECT BORING LOGS FROM WITHIN THE PRELIMINARY SITE PERIMETER

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

Density SAND or GRAVEL	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

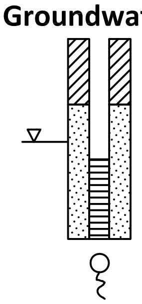
BORING SAMPLES

- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- Grab (Jar)
- Bag
- Shelby Tube

Groundwater Observations



Surface Seal

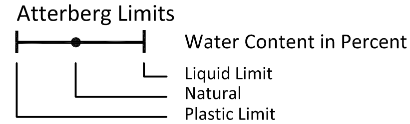
Groundwater Level on Date (ATD) At Time of Drilling

Observation Well Tip or Slotted Section

Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size
Comp	Composite
Chem	Chemistry
NS	No Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	In Situ Density Test



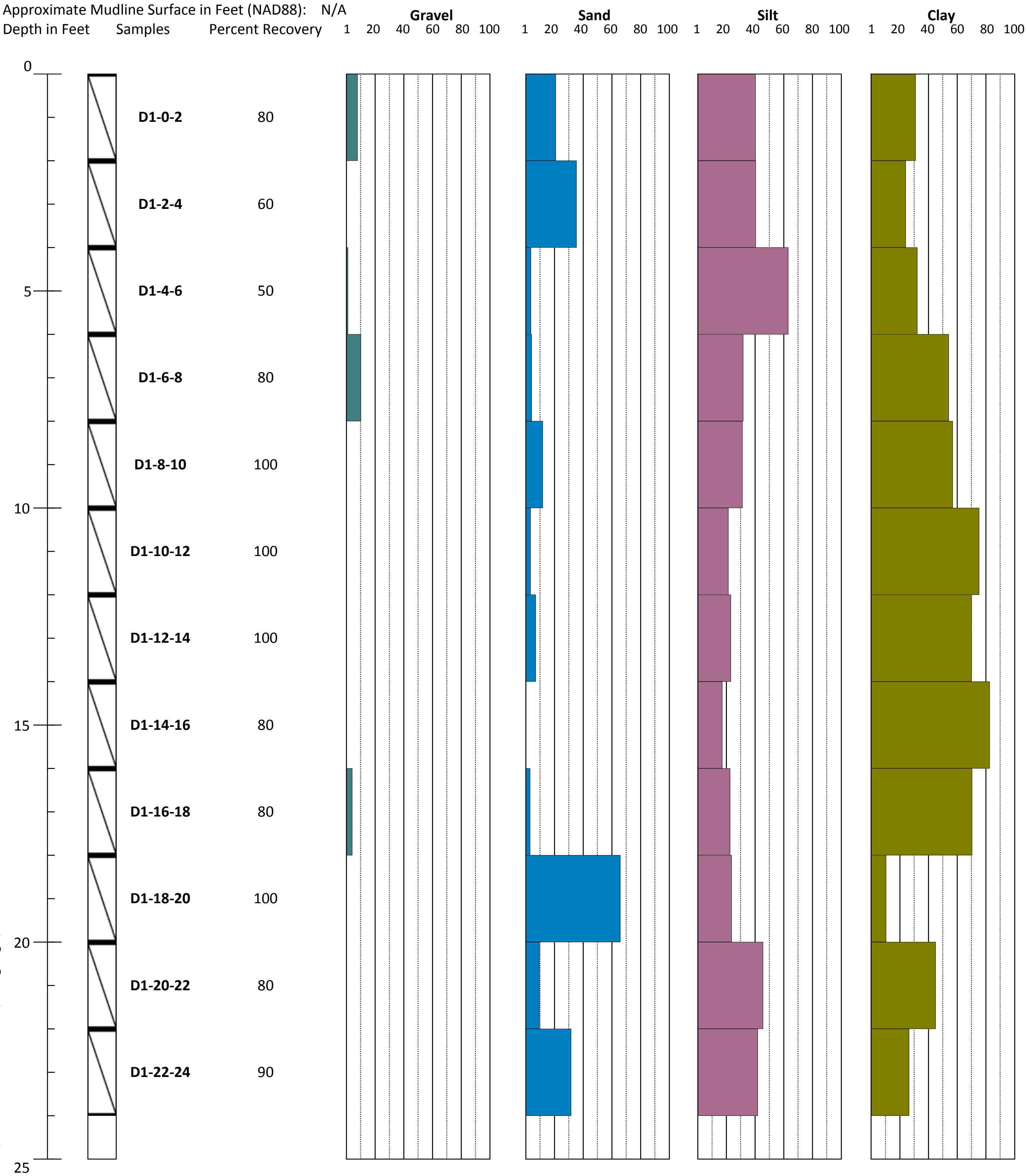
ANCHOR QEA

Figure F-1
Key to Exploration Logs
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: D1

Northing: 13856910.56
Easting: 3217566.34
Approximate Mudline Surface in Feet (NAD88): N/A

Drilling Method: **Shelby Tube**
Date Collected: **6/2/2006**



Notes:
1. Data shown originally reported in “Draft Field Activities Report for Sediment Sampling, San Jacinto river Bridge Dolphin Project” by Weston Solutions, August 4, 2006.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\Boring Logs\GRAIN SIZE LOGS

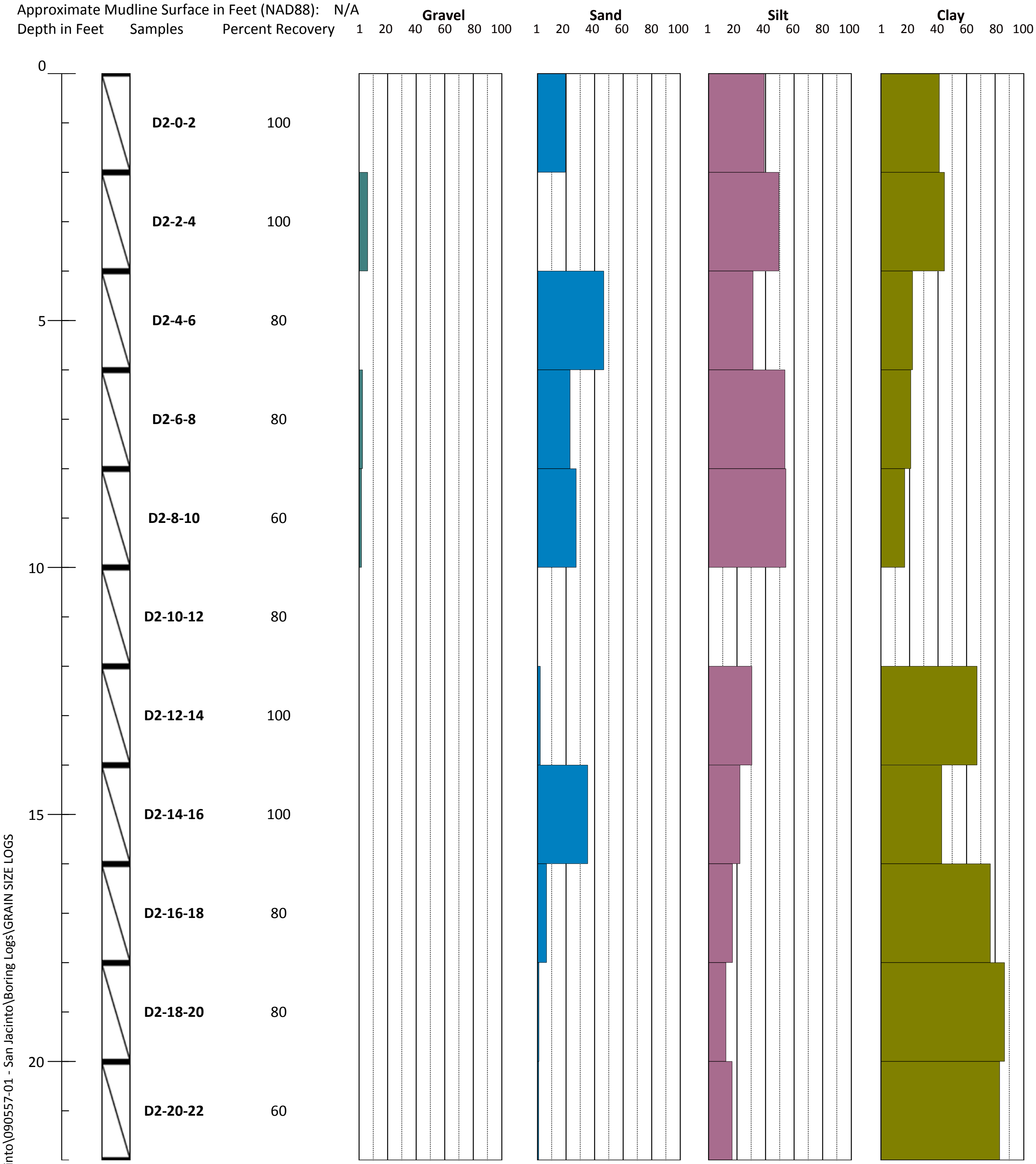
ANCHOR QEA

Figure F-2
TXDOT Boring D1
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: D2

Northing: 13856821.37
Easting: 3217791.49
Approximate Mudline Surface in Feet (NAD88): N/A

Drilling Method: **Shelby Tube**
Date Collected: **6/2/2006**



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Notes:
1. Data shown originally reported in "Draft Field Activities Report for Sediment Sampling, San Jacinto river Bridge Dolphin Project" by Weston Solutions, August 4, 2006.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

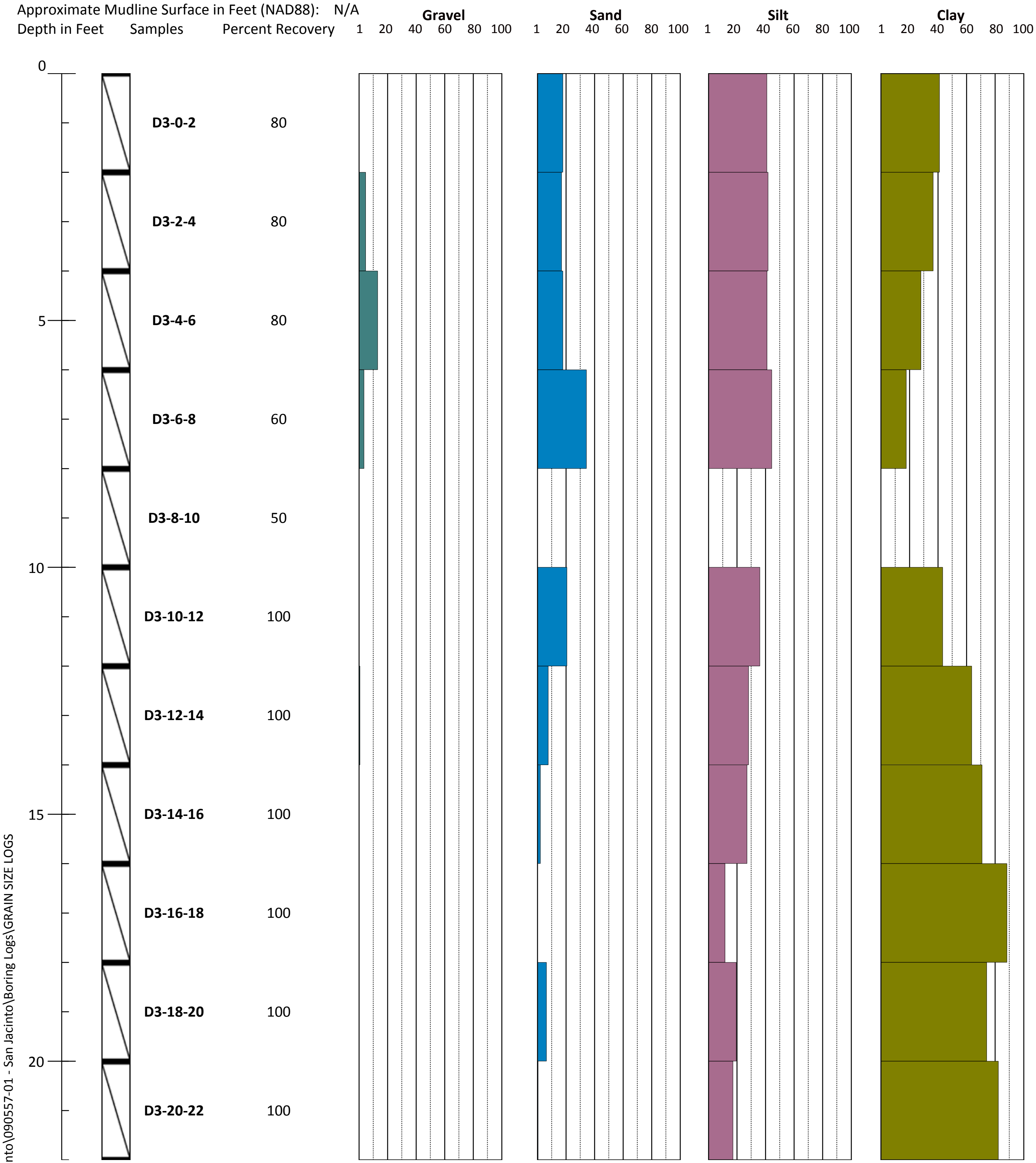
ANCHOR QEA

Figure F-3
TXDOT Boring D2
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: D3

Northing: 13856847.49
Easting: 3217854.08
Approximate Mudline Surface in Feet (NAD88): N/A

Drilling Method: **Shelby Tube**
Date Collected: **6/3/2006**



Notes:
1. Data shown originally reported in “Draft Field Activities Report for Sediment Sampling, San Jacinto river Bridge Dolphin Project” by Weston Solutions, August 4, 2006.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

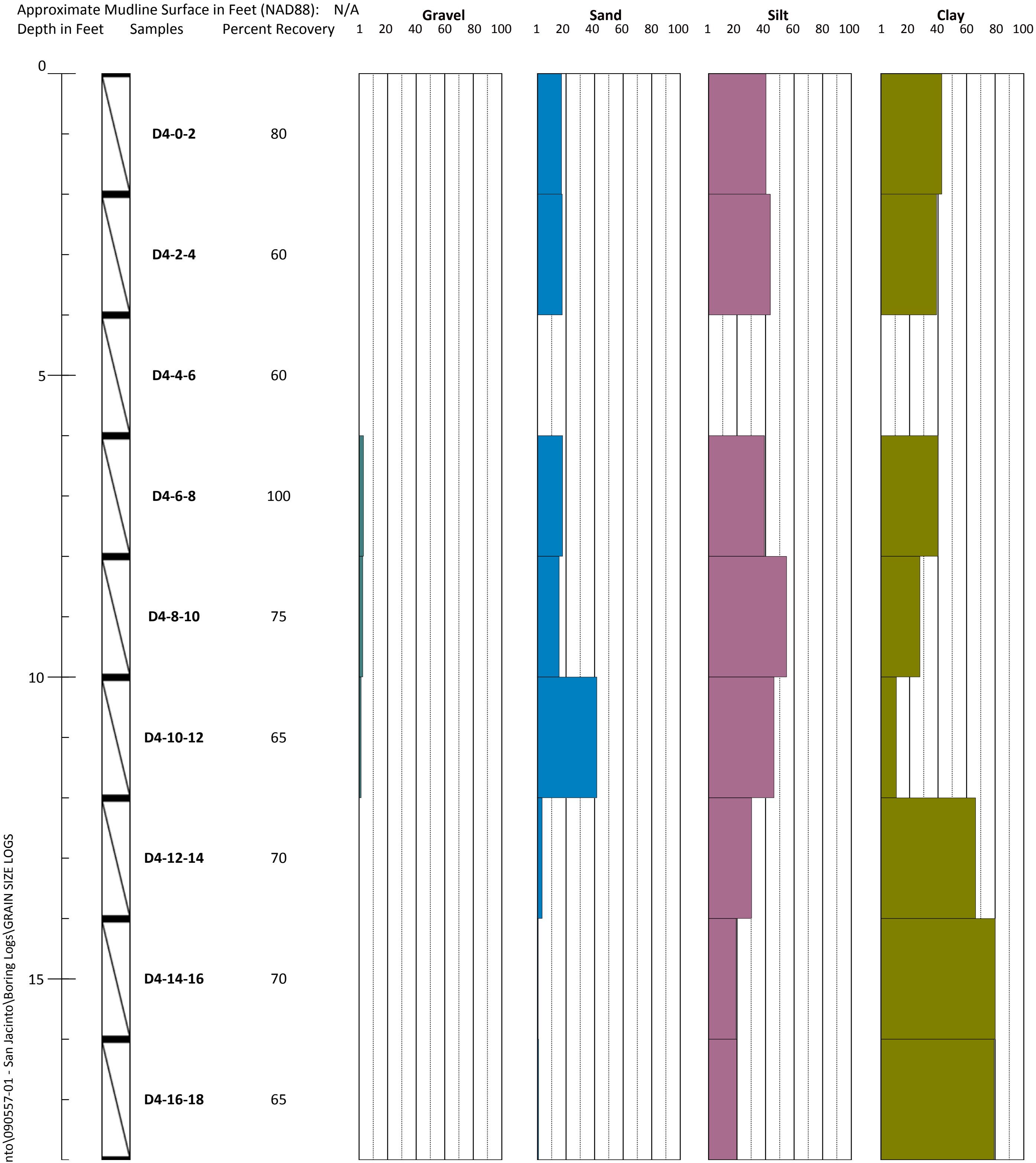
ANCHOR QEA

Figure F-4
TXDOT Boring D3
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: D4

Northing: 13856831.45
Easting: 3217918.09
Approximate Mudline Surface in Feet (NAD88): N/A

Drilling Method: **Shelby Tube**
Date Collected: **5/9/2006 and 5/10/2006**



Notes:
1. Data shown originally reported in “Draft Field Activities Report for Sediment Sampling, San Jacinto river Bridge Dolphin Project” by Weston Solutions, August 4, 2006.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

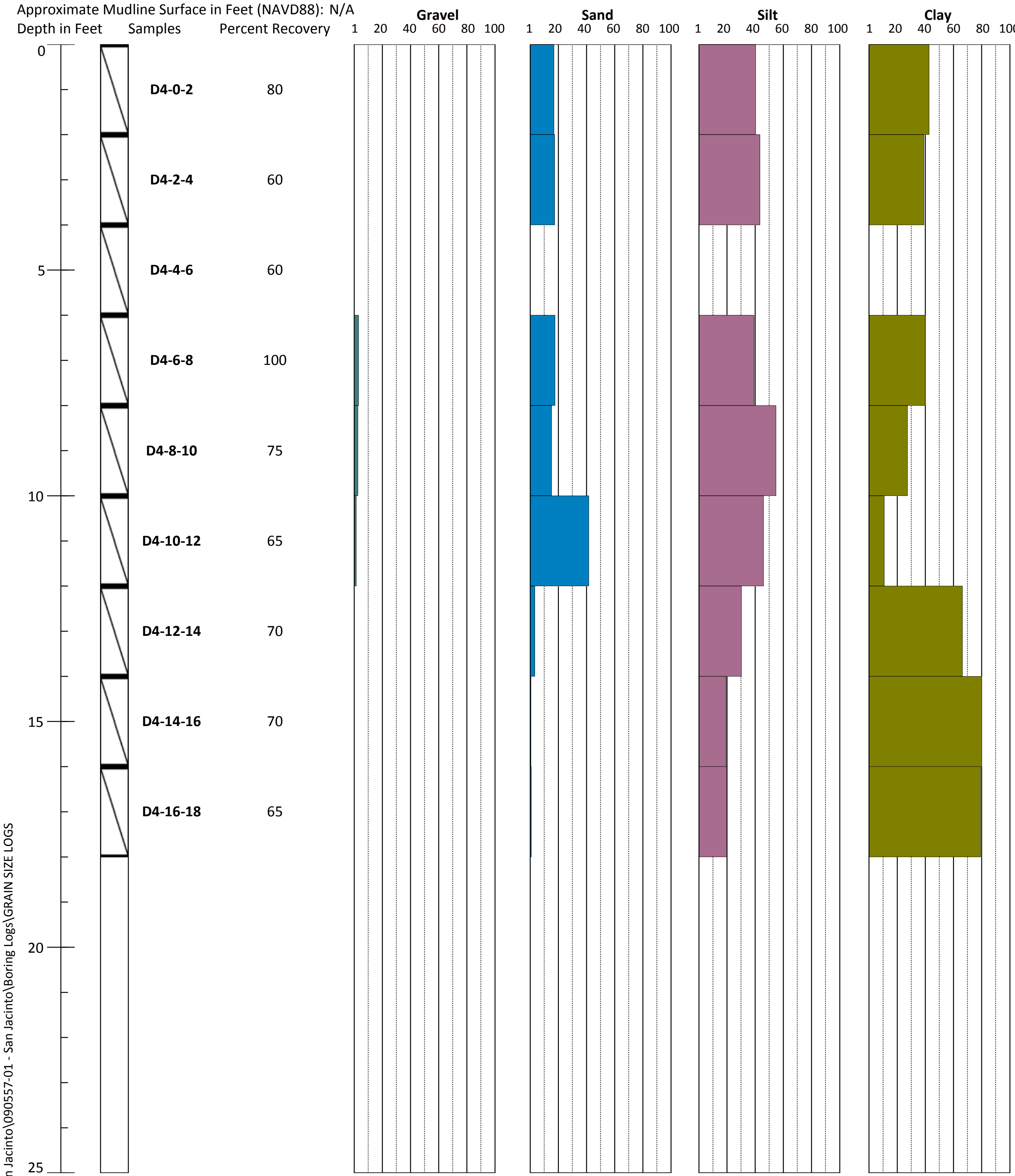
ANCHOR QEA

Figure F-5
TXDOT Boring D4
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: D4

Northing: 13856831.45
Easting: 3217918.09
Approximate Mudline Surface in Feet (NAVD88): N/A

Drilling Method: **Shelby Tube**
Date Collected: **5/9/2006 and 5/10/2006**



Notes:
1. Data shown originally reported in “Draft Field Activities Report for Sediment Sampling, San Jacinto river Bridge Dolphin Project” by Weston Solutions, August 4, 2006.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

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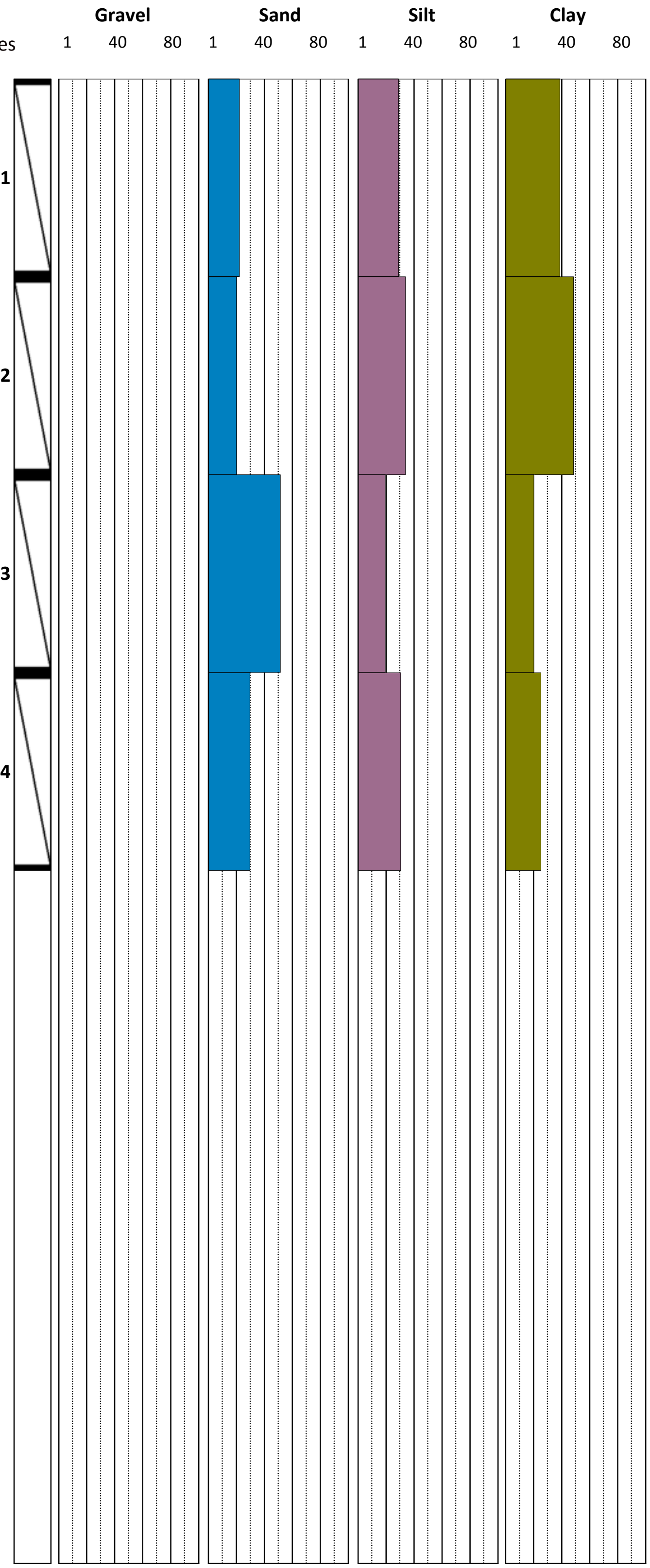
Figure F-5
TXDOT Boring D4
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: SJGB017

Northing: 13857361
Easting: 3217194
Approximate Mudline Surface in Feet (NAVD88):-1.6
(NAD 83 Texas State Plane South Central US Feet)

Date Collected: 5/9/2010

Depth in Feet	Description	Samples
0	Loose, wet, gray, silty SAND. @ 0.3ft.- Wood layer and long, skinny clam in between soils.	SJGB002-01
	Soft, moist to damp, dark gray to black CLAY with trace organic fibers.	SJGB002-02
	@ 3.7 ft.- this gray sand layer in between soils.	
	Soft, dark brownish-gray CLAY with moderate organic fibers.	
5	Soft, wet, gray, sandy SILT with occasional interbeds of black clay. Both Samples S3 and S4 were obtained via SPT sampler after attempts to sample with Shelby tube failed.	SJGB002-03, SJGB002-04
	Sample S5 was collected for geotechnical testing and hasn't been processed yet.	
10	Medium dense, wet, light gray, slightly silty SAND. Poor recovery. Sample S6 was obtained via SPT after attempts to sample with Shelby tube failed.	
	Bottom of boring at 12.0 feet.	
15		



Notes:
1. Surface elevations are calculated based on predicted values from NOAA at the Battleship Texas State Park. Verified data is not available.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

ANCHOR QEA

Figure F-6
Boring SJGB017
SJRWP RI/FS Workplan
SJRWP Superfund/MIMC and IPC

Boring: SJGB008

Northing: 13857202
Easting: 3217339
Approximate Mudline Surface in Feet (NAD88): -3.8
(NAD 83 Texas State Plane South Central US Feet)

Date Collected: 5/6/2010

Very loose, moist to wet, dark gray, clayey, sandy SILT.
@ 0 ft.- contains organics.

Soft, moist to wet, dark gray, fine-grained sandy CLAY.

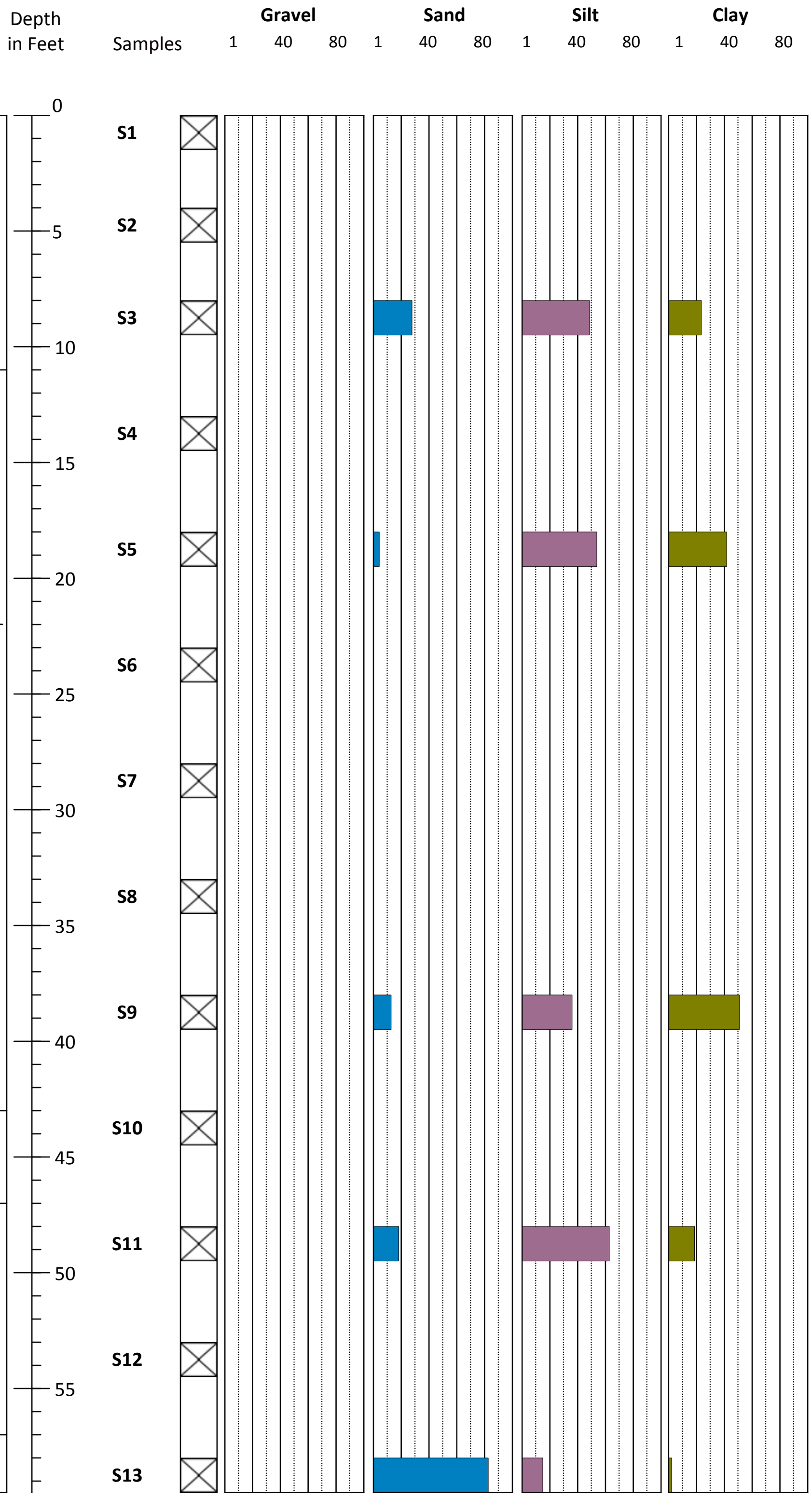
Very stiff to hard, moist to damp, blue gray to reddish-brown CLAY.

@ 28 ft.- grades to reddish brown.

Very dense, moist, light gray, clayey, fine-grained SAND.

Hard, moist, blue-gray, slightly sandy, silty CLAY.

Very dense, moist, blue-gray, clayey SAND.



Notes:
1. Surface elevations are calculated based on predicted values from NOAA at the Battleship Texas State Park. Verified data is not available.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

Boring: SJGB002

Northing: 13857751
Easting: 3216858
Approximate Mudline Surface in Feet (NAVD88): -1.5
(NAD 83 Texas State Plane South Central US Feet)

Date Collected: 5/9/2010

Depth in Feet	Description	Samples
0–6.5	No recovery in upper 4 feet with either Shelby tube or split-spoon sampler. Sample S1 is taken off the surface with a shovel for general characterization. Very soft, wet, dark olive gray, organic SILT with strong chemical-like odor.	S1, S2, S3
6.5–10	Very soft, wet, dark olive gray organic SILT with moderate chemical-like odor.	S4, S5
10–13.5	Medium stiff, damp, light gray with light brown and greenish-gray mottling, sandy CLAY.	
13.5–17	Loose, wet, gray, silty, clayey SAND with slight chemical-like odor.	S6
17–32	Medium dense, wet, light gray with fine black grains, fine- to medium-grained SAND with occasional interbeds of gray clay. Trace to abundant shells grading with depth.	S7, S8, S9
32–59	Hard, damp, light bluish-gray and light reddish-brown, CLAY. @ 38 ft.- trace gravel and sand.	S10, S11, S12, S13, S14, S15
59–	Dense, moist, gray, fine- to medium- grained SAND.	

Gravel: 1 40 80 | Sand: 1 40 80 | Silt: 1 40 80 | Clay: 1 40 80

Grain size data not available

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Notes:
1. Surface elevations are calculated based on predicted values from NOAA at the Battleship Texas State Park. Verified data is not available.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.

Boring: SJGB016

Northing: 13857563
Easting: 3217165
Approximate Mudline Surface in Feet (NAVD88):-2.4
(NAD 83 Texas State Plane South Central US Feet)

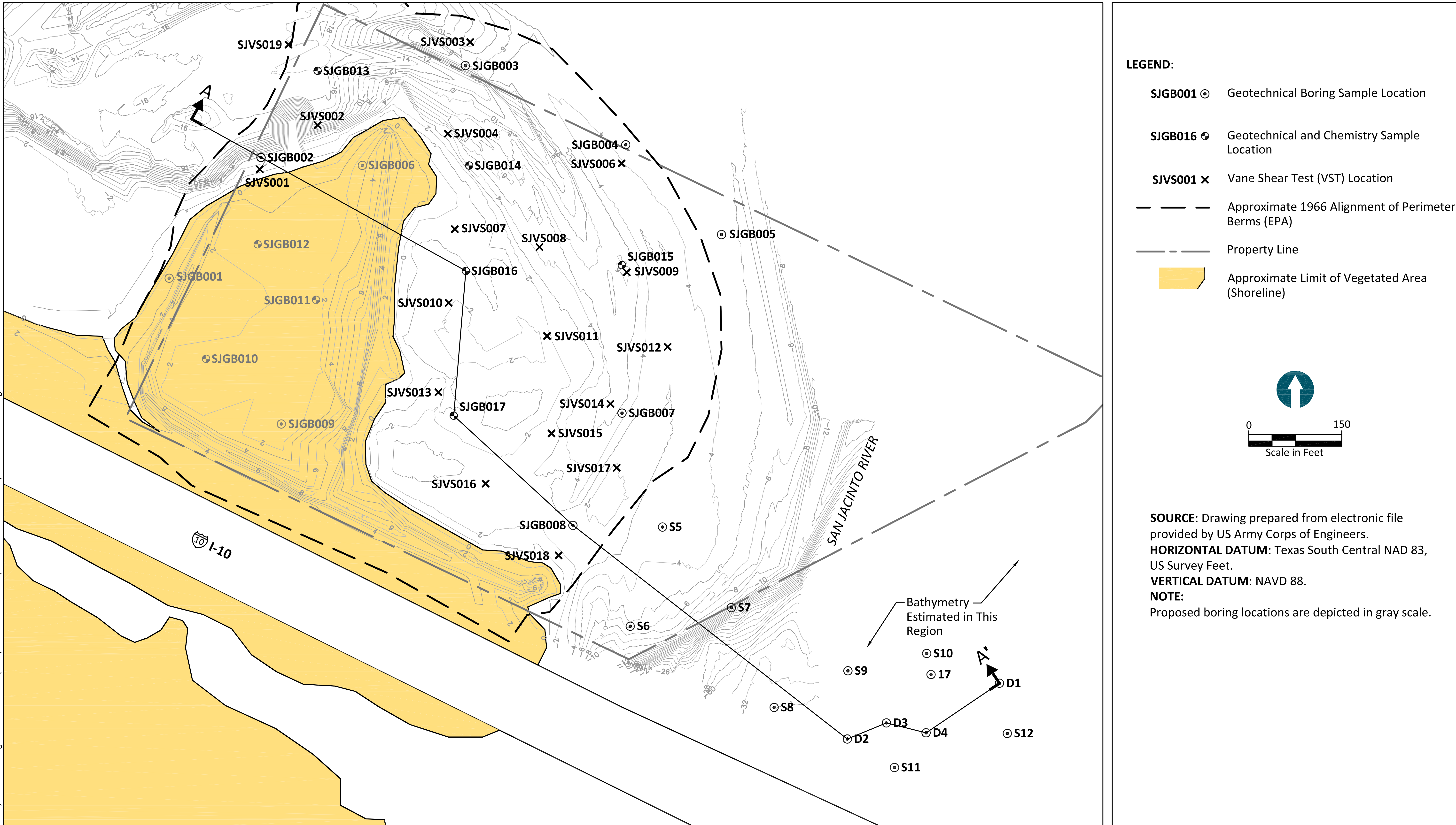
Date Collected: 5/10/2010

Description	Depth in Feet	Samples
Soft, moist, gray, clayey SILT with moderate chemical-like odor.	0	
Soft, moist, dark brown to dark gray organic SILT with moderate wood debris and moderate chemical-like odor.		S1
Soft, moist, dark gray to black CLAY with trace wood debris.		
Soft, damp, dark gray sandy SILT with occasional wood debris and layers (less than 0.4' thick) of loose, light gray, wet sand.		S2
Sample S3 was collected for geotechnical testing and hasn't been processed yet.	5	S3
Soft, wet, gray, sandy SILT with layers of sand and occasional intact shells throughout.		S4
Sample S5 was collected for geotechnical testing and hasn't been processed yet.		S5
Bottom of boring at 12.0 feet.	10	S6

Gravel 1 40 80 | Sand 1 40 80 | Silt 1 40 80 | Clay 1 40 80

Grain size data not available

Notes:
1. Surface elevations are calculated based on predicted values from NOAA at the Battleship Texas State Park. Verified data is not available.
2. Refer to Figure F-1 for explanation of descriptions and symbols.
3. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.



SOURCE: Drawing prepared from electronic file provided by US Army Corps of Engineers.
HORIZONTAL DATUM: Texas South Central NAD 83, US Survey Feet.
VERTICAL DATUM: NAVD 88.
NOTE:
Proposed boring locations are depicted in gray scale.

Figure F-10
Fence Diagram Location Map
Draft RI/FS Work Plan
San Jacinto River Waste Pits Superfund Site/MIMC and IPC

APPENDIX G

RESPONSE TO AGENCY COMMENTS ON THE DRAFT RI/FS WORK PLAN

Comment No.	Section	Page	Line	Comment	Response to Comment - Proposed Revision
EPA-1	Whole Document	All	All	Please see the redline/strikeout version of the Draft RI/FS Work Plan and address each edit.	Each of the redline/strikeout edits were discussed at the June 17, 2010, meeting between EPA, TCEQ, and Respondents to discuss EPA comments on the RI/FS Work Plan.
EPA-2	Section 4.2, Section 6.3			Add language ensuring that biological receptors, associated with the current fish consumption advisories identified in Section 2.3.7.5., is included in both the Human Health Site Conceptual Model and the Baseline Human Health Risk Assessment .	Foot notes will be added to the discussions of CSMs in these sections to indicate that exposure pathways to be evaluated may include ingestion of fish that are the subject of advisories.
EPA-3	Section 8. RI/FS Schedule			Add language ensuring that an updated RI/FS schedule is included with every monthly progress report submittal.	The following statement will be added to the end of the last bullet in the text of Section 8: "Each monthly progress report, starting July 15, 2010, will include the most current version of the project schedule."
EPA-4	Figures 2-1, B-2			CSM and data gaps sections refer to an Upland Sand Separation area to be included in soil data collection. This area, south of the bridge, needs to be sampled as there is evidence that the first pits were located there and that those pits drained into the river.	The "Upland Sand Separation Area" is mentioned only in the legends of two maps. This term was originally used to describe the upland properties west of the impoundments, north of Interstate Highway 10 (I-10). This term was changed in response to comments on the Sediment Sampling and Analysis Plan (Sediment SAP) to "Property West of the Impoundments", which is how it appears in the CSM (Figure 4-1). The map legends will be updated with this term. The specifics of the soil sampling design will be provided in the soil SAP, as noted in Section 1.2.
EPA-5	Figure 4-1			Benthic macroinvertebrates – surface water exposure pathway is deemed incomplete. This is incorrect. Benthic macroinvertebrates are certainly exposed to surface water, especially if they build lined tubes (Leptocheirus plumuslosus) of siphon (mussels) water.	The CSM figures will be modified to show that surface water is a complete exposure pathway for benthic macroinvertebrates.
EPA-6	Figures 4-1, 4-4			If the fisher is exposed to sediment, then they are also exposed to porewater by direct contact. The two cannot be separated. This pathway is complete. The same applies for mammals. If they are exposed to sediment then they are also exposed to porewater.	The CSM figures will be modified to show that porewater water is a complete exposure pathway for people that may be exposed to sediments.
EPA-7	Figure 4-3			This figure must be y-axis log-scaled so the figure reflects points near 100.	The scale of Figure 4-3 will be modified as requested.
EPA-8	Figures 4-5, 4-6, B-6			These figures reflect mammals coming into direct contact with sediments. As such they also come into direct contact with porewater and this needs to be reflected in the figures.	The CSM figures will be modified to show that porewater water is a complete exposure pathway for wild mammals that may be exposed to sediments.
EPA-9	Figures 4-5, 4-6, B-6		Foot- note "b"	Footnote "b" states the assumption that birds and mammals do not ingest surface water because it is estuarine; however, the diagram shows complete pathway for birds. Complete pathway for wading birds is the correct assumption (diagram) regardless of salinity.	Agree.
EPA-10	Figures 4-5, 4-6, B-6			Benthic macroinvertebrates and fish do ingest surface water, therefore, these should be shown as complete pathways. It's not just respiration. When fish eat, they ingest water. This is why freshwater and salt water fish have opposite mechanisms for ridding or conserving body salt concentrations.	The CSM figures will be modified to show that fish and invertebrates ingest surface water.
EPA-11	Whole Document			The following issues needs to be resolved within the RI/FS Work Plan or in the upcoming technical memorandums: • No models are specified for evaluating particle transport and settling, including resuspension. • No test methods are proposed for any clean sediment that may result from the hydrocyclone (can this sediment serve as beneficial use?). • The air pathway seems to be absent during the FS alternatives evaluation. For example: no volatilization evaluation is proposed for the CDF alternative; yet if a CDF is constructed, in-situ or	Our responses include the following, in the order presented by the comment: • Particle transport is addressed by the *Draft Sampling and Analysis Plan Addendum: Chemical Fate and Transport Modeling Study, San Jacinto River Waste Pits Superfund Site* (Anchor QEA 2010) submitted on May 11, 2010. • As discussed in the June 17, 2010, meeting with EPA and TCEQ, it is premature to discuss the use of a hydrocyclone in detail, but text will be modified to indicate that this technology will be considered.

Comment No.	Section	Page	Line	Comment	Response to Comment - Proposed Revision
				mechanical dewatering methods will release volatile compounds. • The disposal option may want to consider geosorbents as possible components.	• Volatile organic compounds have not been found in recent sediment sampling of both surface and subsurface sediments within the waste impoundments. The air pathway is therefore not considered by the RI. • Geosorbents will be considered in the FS; text will be added to Section 7.6 of the document to indicate this.
EPA-12	Section 2.2.5, Geology	Pages 15-17	Second paragraph:	Reference to Figure 2-6 is not correct. The cross-section is shown on Figure 2-7. Additionally, this cross-section is not accurate based on the Table 2, Sediment Characteristics Data, from the TXDOT (Weston) Sediment Sampling Report, San Jacinto River Bridge Dolphin Project, dated 2006. For example, according to Table 2, for deep boring D1 there is a sand layer in the 18-20 foot depth interval. There are other inconsistencies between the Table 2 data and the cross-section interpretation as presented in Figure 2-7. The cross-section needs to be corrected to reflect laboratory sediment characteristic data from Table 2, which is more reliable than a subjective visual field observation. As corrected, the cross-section will show a typical sequence of interbedded and interfingered fluvio-deltaic sands, silty sands, silts, clayey silts, silty clays, and clay layers. As corrected, a cross-section such as this will also illustrate a strong possibility for vertical and horizontal movement of contaminants from the Site into the upper portion of the Chicot aquifer.	A more detailed representation of the groundwater conceptual site model was presented by Respondents at the June 17, 2010, meeting with EPA and TCEQ. The text and figures of sections 2.2.5 and 2.2.6 will be revised to more fully describe the groundwater system at the Site and its geological context, including the geological strata underlying the Site as informed by the TxDOT sediment sampling report (Weston 2006), and new figures and reference materials will be added to better explain the likely groundwater system and potential fate and transport of dioxin in groundwater at the Site.
EPA-13	Section 2.2.5, Geology	Pages 15-17	Second paragraph:	The text and Table 2-2 described three groundwater wells which are within 3,000 feet east and southeast of impoundments. These wells are used for public water supply and are completed in a relatively shallow Upper and Lower Chicot formation. The wells are downgradient from the Site according to the general groundwater flow direction. The investigation should incorporate water quality data for these wells, including the data related to the site contaminants.	The available general water quality data from these wells was evaluated and presented in our meeting with EPA and TCEQ on June 17, 2010. The data showed that the water in these wells was much less saline than surface water from the San Jacinto River, and indicate the Beaumont Clay formation likely acts as an aquitard to prevent downward near surface groundwater and surface water from penetrating into the upper Chicot. It was recognized in the meeting that more recent well water data and measurements of potential contaminant concentrations in groundwater would address data gaps associated with potential fate and transport issues of contaminants in the shallow groundwater, and deeper groundwater in the Chicot Aquifer. The text of Sections 5 and 6 will be revised to reflect these data gaps and recommendations for additional sampling.
EPA-14	Section 3, Assessment of Data Quality and Usability	Page 48:		Regarding historical data relevant to the Remedial Investigation (RI) process, data quality reviews were performed to ensure such data are used appropriately during the RI process. The vast majority of such data was classified as Category 2, generally viewed as of unknown or of suspect quality. It is unclear from the text if the needed QA/QC data is not available, is suspect, or was not contained in the documentation available to the Respondents. Considering the potential value of the historical sediment, surface water, and tissue data to RI modeling efforts on both fate and transport and bioaccumulation, additional effort is warranted to conclusively classify existing data by obtaining the relevant QA/QC information, particularly that generated by the TCEQ TMDL program. This will likely entail independently obtaining the needed information directly from the contractor files.	Detailed data quality analyses will be conducted for those data sets considered relevant to the issues addressed by the RI/FS. Text will be added to the introductory paragraphs of Section 3 to clarify.
EPA-15	Section 4, Conceptual Site Model (CSM)	Page 52:		The text (Section 4.1.1) notes the work of Louchouarn and Brinkmeyer, 2009, regarding locations with very high dioxin levels, such as at the impoundment. Such conditions exceed the sorption capacity of sediments potentially resulting in high levels of dissolved dioxins partitioning to the water column. Future work on fate and transport issues must consider the extended time period that surface waters have been in contact with pulp mill waste, including within the impoundments. This is in addition to evaluation of the partition dynamics between affected sediments and the water column.	Anchor QEA (2010) describes the approach to chemical fate and transport modeling for the Site in greater detail.
EPA-16	Section 4, Conceptual Site Model (CSM)			Based on aerial photographs, TCEQ notes that the impoundments have been at least partially submerged in the San Jacinto River for approximately 37 years and remain so. Given that the San Jacinto River provides about 28% of the freshwater inflow to the Galveston Bay system, it is apparent that such partitioning from pulp mill waste to the water column has the potential to represent significant loading to the system and result in a spatial distribution within both water and tissue that is significantly different than the sediment fingerprinting results of Louchouarn and Brinkmeyer, 2009. The Respondents should provide text indicating that the RI process will evaluate this transport scenario. Furthermore, Figure 4-2 (Physical/ Chemical Fate and Transport Processes) should be revised to show pulp mill waste in direct contact with surface waters.	Anchor QEA (2010) describes the approach to chemical fate and transport modeling for the Site in greater detail, and addresses transport by water. Direct contact of surface waters with the waste in the impoundments is addressed.
EPA-17	Section 4.1.2, Dioxin and Furan	Page 56 and Table 4-1:		Toxicity equivalency factors (TEFs) for dioxins and furans are presented. However, only the 17 dioxin and furan congeners with dioxin-like toxicity are listed. The Texas Risk Reduction Rule TAC§350.76(d)(2)(B)	Details of Site investigations are provided by SAPs, as noted at the end of Section 1.2. The two SAPs submitted so far, the Sediment SAP and the Tissue SAP include the so-

Comment No.	Section	Page	Line	Comment	Response to Comment - Proposed Revision
	Toxicity			states "Further, when congener concentrations are available, the contribution of dioxin-like polychlorinated biphenyls to total dioxin equivalents shall be considered." Please clarify whether new data will be analyzed for congeners since congener data are available for sites outside of the impoundment.	called "dioxin-like" PCB congeners among the chemical analytes, but their analysis in tissue is dependent on results of analysis of sediment chemistry results, as described in Section 1.5 of the Draft Tissue SAP. Section 1.5 of the Tissue SAP also indicates that COPCs may be selected for analysis in tissue if other information is available to suggest that tissue concentrations may be elevated as a result of exposure to contaminants in the waste impoundments. Text will be added to the discussion on page 57 of the Work Plan to clarify under what circumstances dioxin-like PCB congeners will be considered in toxicity assessment, and that TEFs provided by van den Berg (2006, 1998) will be used to evaluate the potential toxicity of PCB congeners, as appropriate. Table 4-1 will not be modified because its purpose is to show the TEFs for dioxins and furans.
EPA-18	Table 4-1, Toxicity Equivalency Factors for Dioxins and Furans			Mammalian TEFs, Avian TEFs, and Fish TEFs all have a reference letter, either a or b. However, there are no footnotes for these references in the Notes section for this figure. Also, it is unclear if "mammalian" includes humans.	The typographical errors will be corrected. Mammalian TEFs are used to address toxicity to humans; this will be noted in the table.
EPA-19	Section 4.2, Human Health Site Conceptual Model	Page 60:		Figures 4-4 and 4-5 are referred to in this section. It is stated that Figure 4-4 is a simple CSM of the release and exposure pathways and that Figure 4-5 presents a CSM exposure diagram for human receptors. However, it appears that Figure 4-4 is the human receptor CSM, Figure 4-5 is the ecological receptor CSM, and Figure 4-1 is the overall CSM.	The typographical errors will be corrected.
EPA-20	Section 4.2.1, Human Health Receptors	Page 60:		It is stated that three potential receptors have been identified for evaluation in the BHHRA: a fisher, a recreational visitor, and a trespasser. As noted in the comments on the Draft Sediment SAP (comment on Figure 6), a distinction needs to be made between the recreational and subsistence fisher pathways. Fish ingestion rates differ between these two pathways and both pathways should be considered.	Both the recreational and subsistence fishers will be included in a revised CSM figure, and text will be edited. Specific rates of ingestion will be discussed in the Exposure Assessment Memorandum, to be submitted on or before December, 2011, as indicated in Section 8 of the Work Plan. This will be noted in the revised discussion of this CSM.
EPA-21	Figure 4-4, Conceptual Site Model for Human Health			The fisher exposure to pore water with dermal contact is considered an incomplete pathway. It is unclear why this would be considered an incomplete pathway while the recreational visitor and trespassers are considered complete.	The CSM figures will be modified to show that porewater water is a complete exposure pathway for people that may be exposed to sediments.
EPA-22	Section 4.2.2, Human Health Exposure Pathways	Page 61:		Due to the lack of information on the Site's groundwater chemistry, an additional potential exposure route should be included for off-site groundwater ingestion. Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans (PCDD/Fs) are hydrophobic organic substances which strongly adsorb to soil particles. Once adsorbed, they are believed to be virtually immobile. However, research in the last decades has confirmed that strong sorbing contaminants may reach the groundwater via colloid-facilitated transport.	A more detailed representation of the groundwater conceptual site model was presented by Respondents at the June 17, 2010, meeting with EPA and TCEQ. The text and figures of sections 2.2.5 and 2.2.6 will be revised to more fully describe the groundwater system at the Site and its geological context. On July 17, 2010, TCEQ provided Respondents with a research citation to support statements in the comment about colloidal transport of dioxins and furans. This and related research, if found, will be included in the revised discussion.
EPA-23	Section 4.2.2, Human Health Exposure Pathways	Page 61:		Figure 4-5 indicates that consumption of fish by recreational visitors is the only incomplete exposure pathway identified. The figure being referred to appears to be Figure 4-4 rather than Figure 4-5. Also, in Figure 4-1 and 4-4 the fisher dermal exposure to pore water is considered incomplete, and in Figure 4-1, only the recreational visitor exposure to surface water is considered incomplete.	The typographical errors will be corrected.
EPA-24	Section 4.3 Ecological Site Conceptual Model	Page 61:		TCEQ recommends an additional mammalian measurement receptor is necessary to adequately characterize risk in the BERA; specifically, the marsh rice rat should be included due to its likely presence, moderate body weight, and partially carnivorous diet. We note that their diet includes fiddler crabs, fish, and clams.	Agree, the marsh rice rat will be added to the list of ecological receptors.
EPA-25	Section 5, Study Elements and Data Needs	Page 64:		Study Elements 1 through 3 need to include groundwater for consideration.	A more detailed representation of the groundwater conceptual site model was presented by Respondents at the June 17, 2010, meeting with EPA and TCEQ. The text and figures of sections 2.2.5 and 2.2.6 will be revised to more fully describe the groundwater CSM for the Site.

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					As agreed at the meeting on June 17, 2010, with EPA and TCEQ, the approach outlined in the response to Comments 13 and 22 will address the most immediate uncertainties associated with groundwater at the Site, i.e., whether there is contamination of off-site wells that access the Chicot or Evangeline aquifers with dioxins and furans from the Site, resulting in a complete exposure pathway via deep groundwater. Chemical concentrations in shallow groundwater at the Site are not considered a data gap in Section 5 for Study Elements 1and 2. Groundwater will not be evaluated for Study Element 2, Exposure Assessment because shallow groundwater is non potable and does not represent a complete exposure pathway to human receptors. Generally speaking, exposure of ecological receptors to shallow groundwater in an estuarine environment would occur as the groundwater moves through surface sediment, i.e., as sediment porewater. As described in the response to comment 31, it is not necessary to directly measure porewater chemistry to address exposures of ecological receptors to dioxins and furans in porewater.
EPA-26	Figures 4-1 and 4-2			Groundwater needs to be included in the exposure media and the physical/chemical fate and transport processes.	Please see the response to Comments 13, 22, and 25.
EPA-27	Figures 4-4, 4-5, and 4-6			Groundwater needs to be included as a separate exposure media.	Please see the response to Comments 13, 22, and 25.
EPA-28	Section 5.2.2, Sediment Data Gaps	Page 68:		PCBs are not mentioned in this section as being part of the primary COPCs, even though they are clearly identified as a primary COPC elsewhere. It is also stated that sediment data within the impoundments are extensive; however, as stated in the Sediment SAP and in Appendix C, PCB congener data are not available for sediment data within the impoundments, which is why they are being collected and analyzed. Therefore, it is unclear if this is viewed as a data gap. Also, please clarify whether future samples will be analyzed for PCB congeners.	Text in Section 5.2.2 will be clarified to indicate that concentrations of PCBs in sediments at the Site are considered a data gap. Please also see the response to Comment 17.
EPA-29	Section 5.2.3, Water Data Gaps	Page 69:		It is stated that human exposures via water are considered negligible because people are not expected to ingest substantial quantities of water from the Site. This is a known swimming and recreational area. In the Texas Risk Reduction Rule TAC§350.71(c) it states "The person shall develop PCLs for each of the following human health exposure pathways which are complete or reasonably anticipated to be complete."	The first paragraph of Section 5.2.3 will be modified to remove language suggesting a premature conclusion of the risk analysis, i.e., that human exposures via surface water are negligible. The sentence will be revised to the following: "Human exposures via ingestion of water may be low relative to exposures resulting from ingestion of contaminated sediment and tissue from the Site because people are not expected to ingest…"
EPA-30	Section 5.2.4, Tissue Data Gaps	Page 69:		While it is realized that more details will be provided in the Tissue SAP, please be aware that one main objective of cleanup of the Site is to remove the fishing advisories that provide protection of the consumption of edible fish and shellfish by humans. Therefore, tissue samples should include the species representative of those advisories for this area: catfish and blue crab.	Catfish and blue crab are included among the tissues to be sampled at the Site, as described in the Tissue SAP.
EPA-31	Section 6.1.2 Surface Water Investigation	Page 79:		The discussion indicates that if the analysis of sediment and tissue data from the Site indicates that potential risks are not adequately explained by sediment exposures, then the chemical fate and transport model will be used with partitioning parameters to predict dissolved concentrations of COPCs. The text goes on to state that if large uncertainties in risk assessment results are due to the use of these estimates, then confirmatory sampling of water quality conditions may be considered in a future phase of site investigation. The Respondents may also want to consider collection of sediment pore water samples in and adjacent to the pits to evaluate dissolved dioxin/furans in the pore water as an exposure medium and source medium (for releases to the water column).	As discussed and agreed at the June 17, 2010, meeting with EPA and TCEQ, it is not necessary to measure dioxin and furan concentrations of dioxins and furans in porewater to evaluate exposure to human or ecological receptors because: • Exposure of ecological receptors will be evaluated by measuring tissue concentrations in surrogates for those ecological receptors that could be directly exposed to sediment porewater. • The literature reviewed in Attachment 2 to Appendix B of the RI/FS Work Plan shows that 2,3,7,8-TCDD is not toxic to benthic invertebrates at or below the solubility level. Any measured concentration would below both solubility and toxicity thresholds for benthic invertebrates.

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					• Evaluation of human exposures to porewater is inherent in the method that will be used to evaluate dermal contact exposures in sediment because the sediment in contact with the dermis is assumed to be wet. Whether measured concentrations of dioxins and furans in porewater is a data gap, will depend on results of the first two steps of the chemical fate and transport analysis. This series of decisions will be clarified in the text of the Work Plan.
EPA-32	Section 6.1.3.1 Tissue Sampling and Analysis	Page 80:		Sediment ingestion is indicated as a minor pathway for omnivorous fish (Fig 4-6). The Respondents may want to consider collection of striped mullet (Mugil cephalus). Although these fish do migrate, they are important forage fish along the Gulf Coast and sediment exposure is maximized since adults commonly feed by sucking up the top layer of sediment.	Respondents agree that mullet is a good (if conservative) indicator of fish exposures due to sediment ingestion. The Tissue SAP targets catfish, and includes the mullet as a surrogate if catfish cannot be found or captured for the study.
EPA-33	Section 6.1.3.1 Tissue Sampling and Analysis	Page 80:		Text should state the intent to analyze tissue samples for PCB congeners, in order to determine total dose to compounds with dioxin-like toxicity in the BERA (EPA, 2008).	Please see the response to Comment 17. PCBs are secondary COPCs because they were never detected in sediments from within the impoundments, but they are potentially bioaccumulative. However, there are no data for PCB congeners in sediments from within the impoundments; existing data report concentration of Aroclors. PCB congeners are included among the analytes for sediments as described in the Sediment SAP. Results of the sediment sampling will provide additional information on PCB congeners, and the potential for exposure to PCB congeners due to contact with sediments from the impoundments can be evaluated. The text of Section 6.1.3.1 will be edited to clarify the process for selection of chemical analytes in tissue, and will be consistent with the text of Section 1.5 of the draft Tissue SAP.
EPA-34	Section 6.4 Baseline Ecological Risk Assessment	Page 102:		Please clarify if a BERA Workplan will be part of the RI process.	A BERA Work Plan is not required by the UAO, and is therefore not planned for this project. Details of the study designs are presented in SAPs, and the data quality objectives in each SAP explain the relationship of the targeted data to the risk assessments. Text will be added to the end of Section 1.2 to clarify this.
EPA-35	Section 6.4.3.1 Aquatic Life	Page 106:		The discussion indicates that to evaluate exposure of fish through ingestion, concentrations of COPCs in each ingested medium (food and sediment) will be compared to the toxicity reference value (TRVs) expressed as dietary concentrations (mg/kg diet). The TCEQ is primarily aware of effect levels for fish in terms of residue levels. How will TRVs (as dietary concentrations) be derived for fish?	Recently, a Pellston Workshop was convened by the Society of Environmental Toxicology and Chemistry (SETAC) to discuss the use of critical tissue residues as a means to assess toxicity to aquatic organisms. The workshop concluded that, with few exceptions, critical tissue residues are not an appropriate means to evaluate toxicity to aquatic organisms for metals. Therefore, metals TRVs for fish will be expressed as a concentration in the food of fish. In addition, several polycyclic aromatic hydrocarbons (PAH) compounds are secondary COPCs, and may require evaluation in the risk assessment. Use of critical tissue residues for PAHs can also be problematic, since fish can metabolize and excrete many of these compounds, while ingestion exposures may be associated with effects. The method described in Section 6.4.3.1 will be used primarily for metals and PAHs, if necessary, as a result of analysis of sediment chemistry, will be clarified in the text of this section. The method may be used for other organic compounds if a reasonable ingestion exposure-response relationship is available for an organic chemical in the literature. TRVs will be derived on the basis of feeding studies in which the subject toxicant is administered to test subjects in their food.
EPA-36	Section 6.4.3.2 Aquatic-dependent Wildlife	Page 106:		Please define, “UCR” as depicted on page 107.	This is a typographical error and will be corrected.
EPA-37	Section 6.4.4 Measures of Effects	Page 108:		The TCEQ recommends avian receptors be evaluated using both a total dose Hazard Quotient approach and the proposed egg critical tissue residue approach.	Agree. Text throughout Section 6.4 will be checked and edited to include this measure of exposure for birds.

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EPA-38	Section 6.4.4 Measures of Effects	Page 108:		Text recommends sole reliance on the critical tissue residue approach to evaluate effects on fish from dioxin exposure. The TCEQ recommends an additional line of evidence be included in the form of toxicity tests that evaluate early life stage effects on fish from dioxin exposure. For example, the EPA Region 6 Calcasieu Estuary BERA performed 48-hour sediment pore water toxicity tests with redfish (Sciaenops ocellatus) embryos based on an endpoint of hatching success and survival.	The toxicity of dioxins and furans to fish, including early life stages is well described in the literature. A site-specific toxicity test for fish was required at the Calcasieu Estuary because of the mixture of numerous contaminants in sediments at the Site, and resultant uncertainty as to the degree of toxicity, due to exposure to multiple contaminants. For this Site, unless sediment chemistry indicates otherwise, dioxins and furans are considered a reliable indicator chemical group for the RI/FS. In light of the extensive literature available, and the difference in COPCs between the Calcasieu and San Jacinto sites, literature-derived TRVs compared to measured concentrations in fish tissue will be used to assess dioxin and furan risks to fish.
EPA-39	Section 6.4.5.4 Characterization of Background Risks	Page 113:		Text states background ecological risks will be characterized based on both upstream and regional conditions, as determined to be necessary based on risk characterization results. Previous comments have provided TCEQ concerns regarding the potential for upstream sediment and tissue to have been affected by the Site. Regarding the use of regional background, the area fishery is currently subject to a fish consumption advisory and multiple regulatory programs are attempting to lower tissue concentrations. These factors indicate development of a regional background concept within the affected area will be of limited value in determining the need for remedial action or protectiveness of current conditions. Also, the full extent of the area impacted by the Site is undetermined; the spatial effects of site contaminants to the water column and tissue are expected to be distinctly different than that of sediment, and will need to be considered in determining appropriate use of background. Text should be revised to reflect these realities.	A detailed discussion of the uncertainties and data gaps about the quality of sediments and tissue upstream of the Site was presented at the June 17, 2010, meeting with EPA and TCEQ. It was agreed that, due to existing data gaps, conclusions about the appropriateness of the upstream area as a background location for use in the RI/FS are premature. Therefore, no changes to the text are required.
EPA-40	SLERA Section 3.2.1 Benthic Macroinvertebrates	Page B-25:		The discussion on page B-25 states that dioxins and furans will be considered in the evaluation of risks to benthic macroinvertebrates in the BERA based on the information provided in Attachment B2 to this SLERA. Table B-4 should be revised to indicate that dioxins and furans will be retained as a COPC for benthic invertebrate community.	This table (and related tables) will be revised to show that exposure of benthic macroinvertebrates dioxins and furans will be evaluated using tissue concentrations and that risks to benthic macroinvertebrates will be assessed on the basis of tissue measurements.
EPA-41	SLERA Attachment B1			Species That May Be Expected in the Vicinity of the San Jacinto River Waste Pits Site: Looking at the attached tables, a number of state or federally listed threatened or endangered wildlife species could occur in the vicinity of the Site. The Respondents will need to determine if these species could occur at the Site, based on the habitat needs of the receptor. If the receptor cannot be ruled out, the BERA should designate a surrogate species for the protected species and base any hazard quotient calculations or risk characterization on the NOAEL TRV or equivalent.	Agree. Text of Appendix B and Attachment B1 will be modified to address the appropriate surrogate species for any listed species that may occur at the Site.
EPA-42	Whole Document - Est.			The RI/FS Work Plan should consider all appropriate removal actions and remediation solutions with equal weight and not be slanted toward use of a Confined Disposal Facility (CDF). Alternatives such as excavation and off-site disposal of the source waste fill need to be addressed more fully. This comment relates to Section 1.2.1 - Site Management, Section 5.4 - Study Element 4: Engineering Design Evaluation, Section 6.1.1 – Sediment, and Section 7.6.4 -Disposal Technologies.	Agree. Text will be modified as indicated for this subject in EPA's redline edits to the word file.
EPA-43	Whole Document - Est.			The evaluation of remedies should consider applicable federal requirements such as flood impacts of any proposed structure (if a structure that blocks additional flow area of the river is selected) as well as the stability of the I-10 bridge (if additional scour is introduced by a restriction of the upstream flow area caused by a remedy).	Agree. The text in Section 7.3 will be modified to reflect this requirement.
EPA-44	Section 2.1 - Est.			The RI/FS Work Plan does not address the following two sites that should be incorporated into this plan: • As per an interoffice memo of the State Health Department concerning an investigation conducted on April 22, 1966, the same waste as contained in the SJRWPSS was also deposited in a pit located south of the Superfund Site. As this waste fill may represent a similar threat to the human health and the environment and was the waste generated by Champion Paper Company, this location should also be investigated for inclusion in the scope of this RI/FS Work Plan. This location is currently described as Tract 4J of Abstract 330 of the J.T. Harrell Survey. • As indicated by review of aerial photos, some type of pit excavation and filling occurred on what is now described as Tracts 4F and 4F-1 of Abstract 330 of the J.T. Harrell Survey. A pit appears to be under excavation as indicated in a 1964 aerial photo, and from additional aerial photos, was filled between 1966 and 1969, with possible additional filling between 1969 and 1973.	See attached.

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EPA-45	Whole Document - Est.			The report cited as Louchouarn and Brinkmeyer (2009), is a study on Phase I of a multi-year study designed to examine the sequestrations and microbial degradation of dioxins in the Houston Ship Channel/Galveston Bay (HSC/GB) system. The conclusions of this report on page 13 ends with the following statement: *'Although this work is based on empirical sorption coefficients that are relevant to the environment of study, accurate porewater concentrations (and thus bioaccumulation potential) need to be measured directly before any meaningful risk assessment and remediation strategy are to be devised.'* Thus, reliance on this source should be tempered with this limitation and cited only when appropriate. In particular, the statements attributed to this cited report in Section 4.1.1 Page 54, Section 4.1.3, Page 58, and Section 6.1.2, Page 79 should be revised recognizing this limitation.	Citation of Louchouarn and Brinkemeyer (2009) in Section 4.1.1 discusses only modeling results, comparing outcomes with different assumptions, and not addressing risk. The discussion on page 58 describes fingerprinting results. The discussion in Section 6.1.2 in which this report was cited was deleted by EPA. For the topics discussed in Section 4.1.1 and 4.1.3, the quote provided in the comment is not relevant. It will be added to the text of Section 2.3.7.1, where the content of the quote is relevant to the overall discussion.
EPA-46	Section 2.1	Page 10, Site History.		This section omits a critical fact regarding discharges of waste from the Site. A sentence should be added to this paragraph to the effect that some waste was pumped from the Site into the San Jacinto River as noted in a letter to MIMC from the Harris County Health Unit dated December 28, 1965.	The requested edit will be made.
EPA-47	Section 2.1	Page 10, Site History.		This section describes the Site as having "late successional stage estuarine riparian vegetation." During a Site visit, the Site seemed dominated by hackberry trees which are often considered pioneer or early successional stage trees in this portion of the State of Texas. The basis for the characterization of the Site as having vegetation characteristic of a late successional stage should be validated to verify this description. This description is also used in Section 2.2.2.	The subject text will be edited to delete the words "late successional stage."
EPA-48	Section 2.2.3	Page 13, Land Use.		This section states: "There are three registered point sources of dioxins and furans upstream of the Site on the San Jacinto River and one immediately downstream (Figure 2-4: Table 2-1)." It is not clear what references are used for these registrations. Defining other sources of dioxins and furans is an important part of this study and the other sources need to be carefully defined with supporting documentation.	Revisions to this section were discussed with EPA and TCEQ on June 17, 2010, at a meeting to discuss these comments. This section will be substantially revised to describe the following: • Locations of facilities upstream of the Site with discharge permits • Locations of sludge and effluent samples that were collected by the TMDL program upstream of the Site. • The text and table will be clarified as to whether the presence of dioxins and furans or their permitted release has been verified in permit records of by the sludge/effluent sample. Appropriate documentation, requested by the comment, will be provided.
EPA-49	Section 2.2.7	Page 18, Surface Water Use.		This section states in the first paragraph, "Fish consumption in the San Jacinto River, both up and downstream of the Site is restricted . . . ." The language in the RI/FS Work Plan suggests that there is some governmental agency which is patrolling the area to dissuade fish consumption. Harris County requests that this language be clarified to convey that the Texas Department of State Health Services places fish advisories recommending limiting fish consumption. However, fish consumption is only restricted by the amount that local fishers can catch. To date, the only action undertaken to restrict fishing has been advisory signage and the recent addition of a fence along a portion of the shoreline.	Text will be revised to provide the requested clarification.
EPA-50	Section 2.2.7	Page 18, Surface Water Use.		This section focus only on water use designation which does not let the whole story. Table 2-3 is not helpful because it does not use terminology common to Clean Water Act and it oversimplifies by not showing where the impaired segments (assessment units) are located (especially as related to the Site). Words such as suitable, unsuitable, approved or restricted should be replaced with impaired or designated where appropriate. The focus also should be on impairments specific to the segments affecting the site (i.e. not contact recreation in unrelated segments).	The text will be edited to use the language suggested by the comment, and information on areas fairly distant from the Site will be deleted.
EPA-51	Section 2.3.2	Page 24, Sediment.		Fourth paragraph references a county wastewater treatment facility. Harris County, the governmental entity, does not own or operate this facility. Please properly identify the owner of this wastewater treatment facility.	The text will be corrected.

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EPA-52	Section 2.3.2	Page 25, Sediment.		In this section is the statement: "Tidal dispersion may lead to some upstream transport and mixing, but the aggregate downstream movement of the sediment in the San Jacinto River system appears to limit the potential influence of downstream sediments on conditions within the Site (Louchouarn and Brinkmeyer 2009)." This statement does not appear to be supported by the cited report. Please verify and revise as needed.	The sentence will be modified and the citation removed, or the sentence will be deleted.
EPA-53		Table 2-1.		Highlands Acid Pit is listed in this table as a source of dioxin and furans. According to Site description posted on the EPA website summary, these are not listed as primary contaminants. Please verify the presence of dioxins and furans from the Highlands Acid Pit with documentation.	The text will be corrected.
EPA-54	Section 2.3.7.1	Page 30, Louchouarn and Brinkmeyer (2009).		The second paragraph cites conclusions based on the Phase I report of Louchouarn and Brinkmeyer (2009). This cite uses stronger language than the report does. Similarly, the final paragraph in this section uses stronger language than the report. Please adjust the cites to match the level of confidence expressed in the report cited.	The text will be edited to provide the appropriate emphasis, or direct quotations from the cited report to ensure the correct representation of the authors.
EPA-55	Section 2.3.7.6	Page 37, Summary.		The first bullet ends with a statement that is not conditioned as the report cited. This conclusion was based on modeling and was stated in the report with less certainty as the cite. Please adjust the cite to match the level of confidence expressed in the report cited.	The text will be edited to reflect the degree of certainty conveyed by the authors.
EPA-56	Section 2.6.1	Page 45, Historical Context.		Fifth paragraph refers to the "present town of Lynchburg." The town of Lynchburg was the victim of subsidence and no longer exists as such. Please correct this reference in the document.	The reference will be corrected.
EPA-57	Section 4.1.4	Page 59, Global and Regional Dioxin and Furan Sources, Release Mechanisms and Transport Pathways.		The University of Houston and Parsons 2006 report and conclusions should be considered for inclusion and be cited in this section.	The University of Houston and Parsons (2006) is used extensively throughout this document.
EPA-58	Section 4.2.1	Page 60, Human Health Receptors.		The first paragraph in this section states "Fishers include children or adults who consume fish from within the Site boundaries either by boat or from along the riverbanks." Please include wading as a means of harvesting fish and shellfish in this section and revise the associated Figure 4–4 for potentially complete and significant exposure pathway for Fishers to surface water through dermal contact.	The text will be modified to indicate that people may be wading at the Site. The CSM will be updated to show direct contact with surface water as a significant and complete pathway.
EPA-59	Section 6.1.1	Page 76, Sediment.		A large portion of the submerged areas around the Site are areas of sediment deposition from the San Jacinto River. As such, surface sampling of sediments may only sample relatively recent deposits of soils from upstream and not collect historical contamination associated with the Site and core sampling would be needed to verify the character of sediments in this area. In the current sediment sampling plan, core samples are planned to characterize contamination in some of the depositional portions of the San Jacinto River as indicated in Figure 14 of the Final Sediment Sampling and Analysis Plan (SAP) (and Section 2.1, third bullet in the text of the SAP). We recognize that this SAP as a phased approach to detecting contaminants and recommend that if the current plan of core samples in this depositional area detects chemicals of interest (COIs) or chemicals of potential concern (COPCs), that the following locations (illustrated in Figure 14 of the SAP) also be core sampled: SJNE034, SJNE044, SJNE045, SJNE036 and SJNE024.	The Sediment SAP and the associated sampling were complete at the time this comment was received. The requested change to the sampling design could not be made. If unacceptable uncertainties remain after the recently collected data have been evaluated, and it is determined that additional data are needed, the suggested samples will be considered.

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EPA-60	Section 6.1.3	Page 80, Biota Investigation.		We look forward to commenting on the Tissue SAP as referenced in this section; however, our preliminary comments are that the list of species to be collected needs to include a comprehensive list of fatty fish that are consumed by Fishers as well as those with consumption advisories.	The purpose of the RI is to gather information sufficient to make informed risk management decisions, and the design for tissue sampling reflects this. The tissue sampling design is intended to support both risk assessment and statistical analysis of the data to help define cleanup targets. The design requires that the biota sampled have a reasonable probability of spending a majority of their time at the Site, and a fairly close association with the sediment. These design components allow an evaluation of the improvements in fish tissue that will correspond to improvements in sediment quality. Many fish that could occur and be captured and eaten at the Site could have been exposed to dioxins and furans elsewhere in the Houston Ship Channel system, and therefore do not provide the information needed for evaluation of sediment remedial alternatives at the Site. Tissue lipids will be reported with each tissue sample, allowing the extrapolation of the concentrations of lipophilic chemicals in the tissue sampled to estimate concentrations in tissues with higher lipid content, if required. Please also see the response to Comment 30.
EPA-61	Section 6.2,	Page 88, PRG Development.		We agree with using upstream data for preliminary remediation goals; however, due to tidal influence and storm surges since the Site was developed, careful consideration should be given to the upstream sample point(s).	Agree.

LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
Anchor QEA	Anchor QEA, LLC
BERA	Baseline ecological risk assessment
CDF	confined disposal facility
COI	chemical of interest
COPC	chemical of potential concern
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
HSC/GB	Houston Ship Channel/Galveston Bay
Integral	Integral Consulting Inc.
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCDDs	polychlorinated dibenzo-*p*-dioxin
PCDFs	polychlorinated dibenzofuran
PRG	Preliminary Remediation Goal
QA/QC	quality assurance/quality control
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SETAC	Society of Environmental Toxicology and Chemistry
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
TCEQ	Texas Commission on Environmental Quality
TEF	Toxicity Equivalency Factors
TMDL	Total Maximum Daily Load
TRVs	toxicity reference values
TXDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order

Response to Comment No. 44

Comment No. 44 states that two additional pits located south of I-10 should be incorporated into the Work Plan. Respondents object to including the additional pits in the Work Plan for the reasons set forth below. Respondents note that they have already collected six (6) sediment samples in the Old River area south of I-10 that is adjacent to the location of one of the “additional” pits referenced in the comments as part of the April 2010 approved “Sampling and Analysis Plan: Sediment Study San Jacinto River Waste Pits Superfund Site,” and at a minimum, it would be inappropriate to include the additional pits in the Work Plan pending an evaluation of the results of such samples. The results of the sediment sampling are expected to be available within the next 60 days.

The first of the two additional pits identified by EPA as being located south of I-10 is discussed in a May 6, 1966 Texas Department of Health (TDH) report (TDH report). (A copy of this report was provided to EPA by MIMC in response to EPA’s CERCLA 104(e) request for information.) The TDH report refers to the pit south of I-10 as the “older site” and states that this “older site” was operated by Ole Peterson Construction Co., Inc. It states that “ As mentioned, the disposal site is adjacent to the San Jacinto River at the Hwy. 73 Bridge with the older site on the south side of the Highway and the newer site on the North side. The older site was used prior to McGinnes Corp. taking over the operation . . .”.

EPA has not identified any evidence of releases associated with this potential “additional pit,” and has previously stated that it was not intended to be part of the Site. Under the circumstances, addressing this "pit" is inappropriate.

The other "pit" referenced in Comment No. 44 involves what EPA refers to as “some type of pit excavation and filling” that is apparently shown on aerial photos on various dates ranging from 1964 – 1973. This other "pit" is referred to as being located on Tracts 4F and 4F-1 of Abstract 330 of the J. T. Harrell Survey, a different location than the other "pit" (which is described as being on Tract 4J of the Abstract 330 of the J.T. Harrell Survey). The comment does not identify any evidence of waste disposal operations associated with either Respondent in connection with this “pit excavation and filling,” or of any releases associated with it. Thus, there would not appear to be any basis on which to require Respondents to address this second "pit" in the Work Plan.

Due to the absence of any evidence of any releases from any pit(s) located south of I-10 and the absence of any connection to either Respondent of the second pit, Respondents object to the inclusion of the two pits and of the area south of I-10 in the scope of the RI/FS currently being conducted by Respondents.

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EPA-1	2.1			Section 2.1: Site History: Replace language with exactly the following: The Site consists of a set of impoundments approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The set of impoundments is located on a partially submerged 20-acre parcel of real estate on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2-1). USEPA has information that indicates an additional impoundment is located south of I-10. This information indicates the additional impoundment contains material similar to that disposed of in the two impoundments described above. USEPA has not identified any evidence of releases or threatened releases from the additional impoundment. Six sediment samples were taken in the Old River area south of I-10, adjacent to the potential impoundment. The six sediment samples were collected as part of the April 2010 approved "Sampling and Analysis Plan: Sediment Study San Jacinto River Waste Pits Superfund Site," and results from the sampling will be reported as part of the RI/FS process. In 1965, the impoundments north of I-10 were constructed by forming berms within the estuarine marsh, to the west of the main river channel. These impoundments at the Site were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm, into the impoundment located to the east of the central berm (Figure 2-1). The excess water collected in the impoundment located to the east of the central berm was pumped back into barges and taken off-Site. In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were reportedly transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas and unloaded at the Site into the impoundments north of I-10 where the waste was stabilized and disposed. The excess water from these impoundments was pumped back into barges and taken off-Site. The Champion Paper mill used chlorine as a bleaching agent, and the wastes that were deposited in the impoundments have recently been found to be contaminated with polychlorinated dibenzo-p-dioxins, polychlorinated furans (dioxins and furans), and some metals (TCEQ and USEPA 2006); additional discussion of the chemical constituents typical of materials like those deposited in the impoundments is provided in Section 1.5 of the Sediment SAP (Integral and Anchor QEA 2010). The impoundments north of I-10 were used for waste disposal from September 1965 through late 1966, until both impoundments were filled to capacity. Since the eastern impoundment was used to dewater the western impoundment (as noted above), the capacity of the eastern impoundment for waste disposal is thought to have been less than that of the western impoundment. Physical changes at the Site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the impoundments north of I-10 and exposure of the contents of the impoundments to surface waters. Based upon review of U.S. Army Corps of Engineers (USACE)-approved dredging permits, dredging by third parties has occurred in the vicinity of the perimeter berm at the northwest corner of these impoundments. Recent samples of sediment in nearby waters north and west of these impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than levels in background areas nationally (USEPA 2000). Freshwater, estuarine, and marine habitats in the vicinity of the Site are shown in Figure 3. Residential, commercial, industrial, and other land use activities occur within the preliminary Site perimeter and in the surrounding area. Residential development on the eastern bank of the river is present within 0.5 mile of the Site. The impoundments north of I-10 are currently occupied by estuarine riparian vegetation to the	The requested text will be added.

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				west of the central berm, and are consistently submerged even at low tide to the east of the central berm. Estuarine riparian vegetation lines the upland area that runs parallel to I-10 and the uplands west of the impoundments. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2-1).	
EPA-2	4.1.3			Section 4.1.3: Site Related Dioxin and Furan Sources: Second paragraph, first sentence: Remove "contaminated sediments" and replace with "source material". Sentence should read: "Human and ecological receptor contact with source material currently exposed within the boundary of the impoundments is also potentially ongoing."	Requested edit will be made.
EPA-3	4.1.3			Section 4.1.3: Site Related Dioxin and Furan Sources: Add sentence to the end of the second paragraph: "In addition, the CSM will also focus on the permanent cessation of human and ecological receptor contact with the source material."	Requested edit will be made.
EPA-4	6.1.8			Add new section and language specified: 6.1.8 Soil Investigation USEPA has information that indicates an additional impoundment is located south of I-10. This information indicates the additional impoundment contains material similar to that disposed of in the two impoundments located north of I-10. Surface and subsurface soil samples will be taken in and around these impoundments to determine the nature and extent of any actual or threatened releases.	• No evidence of releases or threatened releases from the impoundment located south of I-10 has been identified. In fact, soil and sediment data generated as part of the recent RI/FS and TCRA-related activities indicate that there have been no releases to the environment from the south impoundment (Figure 1). These data include the following: o Preliminary data from recent sampling of soils in the Texas Department of Transportation ("TxDOT") right-of-way on the south side of the I-10 bridge adjacent to the location of the south impoundment show the concentration of 2,3,7,8 TCDD was estimated (i.e. J-flagged) value of 0.55 ng/kg-estimated values indicate concentrations are very close to the analytical detection limit. Conversely, samples taken on the south side of I-10 in the TxDOT right-of-way, and closer to the northern impoundments, had concentrations of 5.76 ng/kg dw and 2.2 ng/kg dw 2,3,7,8 TCDD. o Sediment data collected for the RI in May of 2010 from within the Old River, within 200 feet of shore and to the west of the south impoundment, show very low concentrations of dioxins and furans. 2,3,7,8-TCDD concentrations in the three surface sediment samples west of the south impoundment ranged from 3.10 to 4.98 ng/kg dw. Moreover, the dioxin and furan signature in the sediment samples obtained by the Respondents in 2010 from the three stations directly adjacent to the south impoundment, and of a sediment sample collected in this area by TCEQ in 2005, match the signature characteristic of dioxins and furans in urban background samples, and match the dioxin and furan signature in sediments from

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					the upstream background stations sampled by the Respondents during the RI in 2010. At the nearest station in the Old River, downstream from the south impoundment area, sampled in 2010 during the RI, 2,3,7,8 TCDD was not detected. These results clearly indicate that a release has not occurred from the south impoundment into the Old River. • A substantial amount of fill has been placed over the entire peninsula south of I-10 where the south impoundment may be located, and the land over that fill has been developed by a variety of industrial facilities, manufacturing facilities, boat and ship maintenance operations, parking lots, public roadways and associated right-of-ways. • The fill, buildings, parking lots, and other impermeable surfaces on the peninsula south of I-10 have likely further restricted any potential for releases or threatened releases from the impoundment under consideration.
EPA-5	7.6			Section 7.6: Identify and Screen Remedial Technologies: Add the following paragraphs to the beginning of this section: The material in the waste pits are source materials that contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to ground water, to surface water, to air or acts as a source for direct exposure. (USEPA 1991 "*A Guide to Principal Threat and Low Level Threat Wastes"*). The purpose of identification and screening of remedial technologies is to evaluate cleanup alternatives for all principal threat and low level threat wastes associated with the site source materials and nature and extent areas. USEPA expects to: • Use treatment to address the principal threats posed by a site, wherever practicable. • Use engineering controls, such as containment, for wastes that pose a relatively low long-term threat or where treatment is impracticable. • Use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of principal threats posed by a site, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment residuals and untreated waste. • Use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances.	The requested text will be added.

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EPA-6	7.6			Section 7.6 and subsections: Wherever "dredging" is mentioned, insert "or excavation" afterwards.	The requested text will be added.
EPA-7	6.1.4			Comments related to response grid and integration into RI/FS work plan: EPA-33: This comment had requested that tissue samples be analyzed for PCB congeners in order to determine the total dose to compounds with dioxin-like toxicity. The response reiterates the approach for secondary COPCs and the intent to not analyze for COPCs in tissue if there is a correlation with dioxins/furans in sediment. The text in revised Section 6.1.4 (pages 82 and 83) reflects text similar to that discussed in the Tissue SAP (regarding the correlation approach). The State of Texas has indicated that this is unacceptable (see Tissue SAP: EPA-18 for additional details).	The text in section 6.1.4 has been revised to say the following, with new text highlighted, below: Tissue samples will be collected to support Study Element 2, exposure evaluation, which relates to the baseline human and ecological risk assessments. To identify analytes for tissue samples collected according to this SAP, analysis of sediment data is required, as follows. Results of sediment chemical analyses from the sediment sampling conducted in May 2010 will be generated prior to the performance of tissue sampling. Once validated chemistry data are available for sediments, results for secondary COPCs will be evaluated for frequency of detection in sediments and for statistical correlation with dioxins and furans in sediment that are representative of the wastes in the impoundments (i.e., one or more of the most common congeners in waste-related sediments). Those secondary COPCs never detected in sediment will not be considered in the risk assessments, and will therefore not be measured in tissue. This approach is conservative because several sediment samples are from directly within the waste impoundments. **Secondary COPCs that are detected will be evaluated using risk-based screens, which include consideration of bioaccumulation potential.** Those secondary COPCs that are detected at least once and that statistically correlate with representative dioxin and furan congeners will not be evaluated in tissue, because any risk associated with a secondary COPC that correlates with representative dioxins and furans is likely to be addressed by sediment remediation performed to address risk due to dioxins and furans. As noted for sediment COPCs in the Sediment SAP, these decision rules apply unless additional information indicates that a COPC may be present at elevated levels in tissues on Site as a result of exposure to the waste in the impoundments. For example, PCB congeners **will be** evaluated in tissue, even if they correlate with dioxins and furans, because of the possibility that their toxicity is considered additive with that of dioxins and furans for some endpoints in some species.
EPA-8	6.4.3.1			Comments related to response grid and integration into RI/FS work plan: EPA-35: Text in Section 6.4.3.1 was revised to more specifically reflect the approach for evaluating risks for fish (residue approach versus evaluation of fish exposure through ingestion and comparison to TRVs). However, the reference for USEPA 2007b is not provided in the list of references, and the Meador et al. 2006 reference is incomplete.	The reference for EPA 2007 has been added, and the reference for Meador et al. (2006) has been completed in the reference list.

LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
ACBM	advanced concrete-based materials
Anchor QEA	Anchor QEA, LLC
AOC	area of concern
CDF	confined disposal facility
COI	chemical of interest
COPC	chemical of potential concern
CSM	conceptual site model
DQO	Data Quality Objective
ERL	effect range low
FS	Feasibility Study
FSP	Field Sampling Plan
HH	Human Health
Integral	Integral Consulting Inc.
OSTRI	EPA Office of Superfund Remediation and Technology Innovation
PCB	polychlorinated biphenyl
PCDDs	polychlorinated dibenzo-*p*-dioxin
PCDFs	polychlorinated dibenzofuran
PRG	Preliminary Remediation Goal
QAPP	Quality Assurance Project Plan
RME	reasonable maximum exposure

Abbreviation	Definition
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
SLV	screening level value
TCEQ	Texas Commission on Environmental Quality
TEF	Toxicity Equivalency Factors
TEQ	toxicity equivalent
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TXDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
VST	vane shear test
WHO	World Health Organization